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**PRESERVATION OF
 MONUMENTS
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 SEPTEMBER 2026 | ATHENS, GREECE



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4th International Symposium
 Preservation of Monuments and Historic Sites

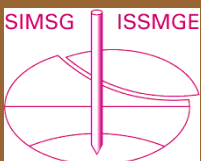
Αρ. 209 – ΦΕΒΡΟΥΑΡΙΟΣ 2026



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Η ιστορία του Νικήτα και της Μάρθας δεν είναι δύο τοπικές τραγωδίες. Είναι μια τελευταία προειδοποίηση από τον παγωμένο Βορρά. Μια προειδοποίηση για όλους μας.

Η ύβρις της ανθρωπότητας – Mankind's Folly

Γ. Αυγερόπουλου



Εκατέρωθεν του Βερίγγειου Πορθμού, ο Νικήτα στην Ανατολική Σιβηρία και η Μάρθα στη Βόρεια Αλάσκα παρακολουθούν τον κόσμο τους να καταρρέει. Το επί χιλιετηρίδες παγωμένο έδαφος, το permafrost, που σφράγισε μέσα του την εποχή των μαμούθ, τώρα ξεπαγώνει με πρωτοφανείς ρυθμούς και κατακρημνίζεται, συμπαρασύροντας ό,τι έχει χτιστεί πάνω του, όλες τις υποδομές του ανθρώπου παντού στην Αρκτική. Σπίτια, δίκτυα ηλεκτρισμού, αγωγοί ορυκτών καυσίμων, δρόμοι, οικισμοί αλλά και ολόκληρες πόλεις κινδυνεύουν.

Ωστόσο, το λιώσιμο του permafrost δεν αποτελεί μόνο ένα τοπικό πρόβλημα που βιώνουν ο Νικήτα και η Μάρθα. Είναι μια ωρολογιακή βόμβα από το παρελθόν που έχει ήδη ενεργοποιηθεί και απειλεί όλο τον πλανήτη. Καθώς το μόνιμα παγωμένο έδαφος ξεπαγώνει, φέρνει στην επιφάνεια τεράστιες ποσότητες προϊστορικών φυτών και ζώων που είχε εγκλωβίσει μέσα του, και οι οποίες αποσυντίθενται στον 21ο αιώνα, απελευθερώνοντας στην ατμόσφαιρα διοξείδιο του άνθρακα και μεθάνιο — αέρια που επιταχύνουν την υπερθέρμανση του πλανήτη.

Την ίδια στιγμή, οι μεγαλόστομες δεσμεύσεις των ηγετών για την κλιματική κρίση ξεθωριάζουν, χαμένες μέσα σε πολέμους και οικονομική αβεβαιότητα. Η «ενεργειακή ασφάλεια» έχει γίνει η νέα προτεραιότητα. Στην Αρκτική, όπου βρίσκονται τεράστια, ανεκμετάλλευτα κοιτάσματα ορυκτών καυσίμων, οι γεωτρήσεις επεκτείνονται πιο γρήγορα από ποτέ. Στη Σιβηρία, η Ρωσία συνεχίζει την παραγωγή πετρελαίου και φυσικού αερίου παρά τις διεθνείς κυρώσεις. Στην Αλάσκα, δίπλα στην κοινότητα της Μάρθας, εγκρίθηκε πρόσφατα ένα τεράστιο έργο εξόρυξης.

Οι επιστήμονες προειδοποιούν ότι η Αρκτική θερμαίνεται τέσσερις φορές πιο γρήγορα από τον παγκόσμιο μέσο όρο. Μιλούν για σημεία χωρίς επιστροφή, για αλυσιδωτές επιπτώσεις που δεν θα μπορούν να ανακοπούν. Όμως οι φωνές τους σκεπάζονται από πολιτικές σκοπιμότητες και οικονομικά συμφέροντα.

Πρόκειται για το σενάριο του ομώνυμου ντοκιμαντέρ του Γ. Αυγερόπουλου (Ελληνικής και Γαλλικής παραγωγής), το οποίο έλαβε *Ειδικό Έπαινο (Special Commendation) - Prix Europa 2025 Βερολίνο στην Κατηγορία Ντοκιμαντέρ*.

Σύντομο απόσπασμα στο

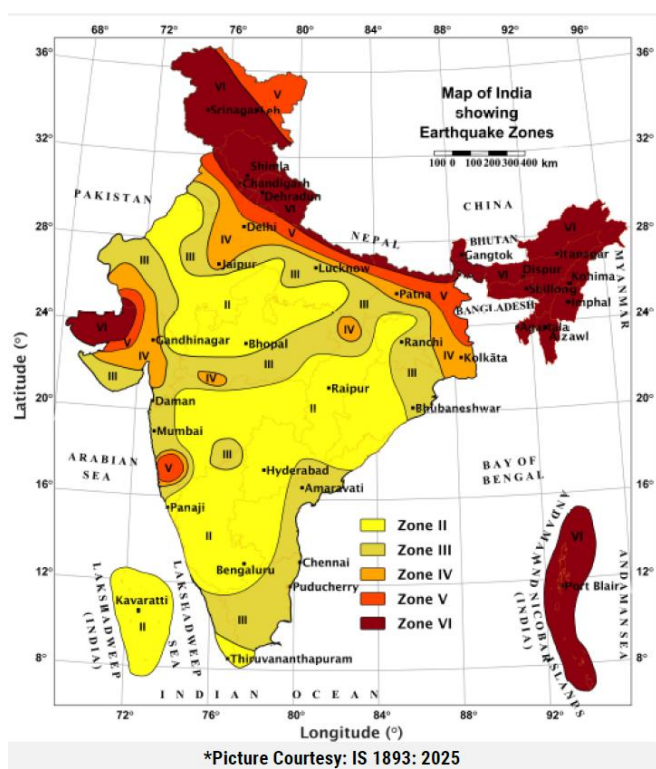
<https://www.youtube.com/watch?v=0Crpl6qMAZ4>

Περισσότερες Πληροφορίες: <https://small-planet.gr/el/film/mankinds-folly/>

Understanding the Procedure to Evaluate Liquefaction Susceptibility - IS 1893 (Part 1): 2025

Prof. Subhadeep Banerjee, Indian Institute of Technology Madras, subhadeep@civil.iitm.ac.in

IS 1893 (Part 1): 2025 introduces an improved framework for assessing soil liquefaction under seismic loading. It evaluates earthquake demand, soil resistance and post-liquefaction settlement using Cyclic Stress Ratio (CSR) and Cyclic Resistance Ratio (CRR). Compared to the 2016 edition, the code expands testing methods, refines correction factors, updates CRR formulations, includes plastic soils and introduces a three-tier safety classification with mandatory settlement checks.



what does the code say?

The 2025 code uses a *simplified procedure* to evaluate the liquefaction susceptibility of the ground during earthquakes. This is essentially a combination of the estimations of three quantities: a. *Demand* (how hard the earthquake shakes the ground), b. *Capacity* (how well the soil can resist that shaking) and c. *Settlement* (how much the ground settles).

A) Cyclic Stress Ratio - Calculating the Demand

The code first looks at the *Cyclic Stress Ratio (CSR)*, which represents the earthquake's demand on the soil. This calculation takes the *Peak Ground Acceleration (PGA)*, the strongest shaking expected at the site, and adjusts it based on the total weight of the soil above and the hydrostatic pressure at that depth. It also uses a *stress reduction coefficient* to account for the fact that soil is not a rigid block; the shaking energy changes as it travels deeper into the ground.

B) Cyclic Resistance Ratio - Determining Soil Capacity

Next, the *Cyclic Resistance Ratio (CRR)* is calculated to find the strength of soils. This is based on conventional field tests

like standard penetration tests, cone penetration tests, dilatometer tests and geophysical tests. This simplified procedure is standardised for a generic earthquake of 7.5 magnitude; the code applies a *Magnitude Scaling Factor (MSF)* to adjust the capacity for the actual earthquake magnitude expected in your specific zone. It also applies an *Overburden Stress Correction Factor* to account for how soil becomes more resistant under the overburden pressure of the deep layers.

C) Settlement - Assessing Safety and Serviceability

Once the *Demand* and the *Capacity* are determined, the factor of safety will be obtained by dividing the Capacity by the Demand.

If the value is below 1.2, the site is labelled as unsafe, meaning the soil is highly likely to liquefy.

If the value is between 1.2 and 1.4, the code says that while the soil might not fully liquefy, it could still settle or sink significantly. In this case, engineers must use the code's volumetric strain charts, which depend on the relative density of the soil layer to calculate exactly how much the ground might sink and whether the structure can handle it.

Only when the factor of safety is above 1.4, the soil is considered to be safe.

How different is it from the 2016 version?

While the primary objective remains the same, the 2025 edition introduces an additional *safety net* by incorporating several technical refinements and a relatively more comprehensive methodology compared to the 2016 version. Some of the salient changes are as follows:

Expanded Testing Methods: While the 2016 code primarily focused on standard penetration test (SPT), cone penetration test (CPT) and shear wave velocity (V_s) measurements using geophysical tests, the 2025 code introduces the *Dilatometer Test (DMT)* as a recognised method for estimating CRR.

Detailed Magnitude Mapping: In the 2016 code, the MSF depends only on the *Magnitude* of the earthquake zone, whereas in the revised 2025 code, it depends on the SPT blow count and CPT resistance along with the magnitude of the earthquake.

Refined Stress Reduction Factor (r_d): The 2025 code uses a modified expression for *Stress Reduction Factor (r_d)* that accounts for both depth and earthquake magnitude, whereas the 2016 code used simpler linear depth-based equations.

Updating $CRR_{7.5}$ in SPT and CPT: In the 2025 version, the formulations for q_{c1NCS} and $(N_1)_{60CS}$ have been revised by incorporating additional incremental correction terms, namely Δq_{c1N} and $\Delta(N_1)_{60}$.

Treatment of Plastic Soils: The 2025 code includes specific empirical methods and formulas for assessing the CRR of clay and plastic silt, which was not accounted for in the previous version.

Categorization of Soil Safety: The 2016 code considered soil safe if the Factor of Safety (FS) is generally ≥ 1.2 . The 2025 code provides a more specific 3-tier safety assessment:

Unsafe: $FS_{liq} < 1.2$

Verify Settlement: $1.2 \leq FS_{liq} \leq 1.4$ (requires checking ground settlement)

Safe: $FS_{liq} > 1.4$

Settlement Calculation: The 2025 code includes settlement of soil layer from the post liquefaction volumetric strain ($\varepsilon_v = \Delta H / H$) where ΔH = Settlement of the soil layer and

H = Height of the soil layer

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Mitigation of Earthquake-Induced Soil Liquefaction Risk by Induced Partial Saturation (IPS)

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Introduction

Earthquake-induced liquefaction occurs in saturated, loose, granular soils due to the rapid buildup of excess pore water pressure under cyclic loading, leading to a significant reduction in shear strength (Kramer, 1996). Liquefaction during moderate to strong earthquakes can cause severe damage, including slope failures, loss of bearing capacity and deformation of soil-retaining structures (Seed et al., 1989; Bird and Bommer, 2004; Huang and Yu, 2013). Conventional mitigation techniques such as dynamic compaction, deep soil mixing, grouting and groundwater lowering are effective but often constrained by high cost, environmental concerns and potential disturbance to existing infrastructure (Cooke and Mitchell, 1999; Bayat et al., 2013). Recent research has therefore focused on non-disruptive ground improvement approaches, including bio-mediated methods and soil desaturation techniques. In particular, controlled desaturation has emerged as a promising, cost-effective and environmentally sustainable strategy for enhancing liquefaction resistance, even beneath existing structures.

Experimental and empirical studies indicate that reducing the degree of saturation from 100% to approximately 98% can increase liquefaction resistance by up to 30% (Okamura and Yasumasa, 2006; Mele and Flora, 2019; Tsukamoto, 2019). Partial saturation can be induced through air injection, electrolysis, chemical treatment and biogenic gas generation. The presence of entrapped air or gas bubbles increases pore fluid compressibility, reduces excess pore pressure accumulation during cyclic loading and consequently improves liquefaction resistance (Ishihara et al., 2003; Okamura and Yasumasa, 2006) (Fig. 1).

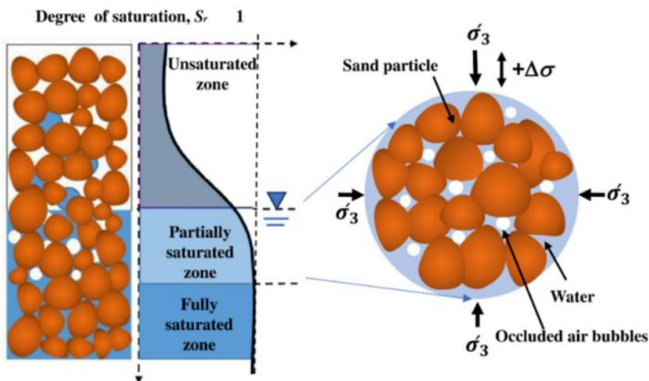


Fig.1: Schematic illustration showing the distribution of saturation states: fully saturated, partially saturated and unsaturated zones

Despite advances in induced partial saturation (IPS), critical gaps persist in understanding monotonic behavior, pore pressure evolution, environmental controls on gas stability, optimal air injection parameters under seismic loading and long-term, large-scale field performance. This study systematically evaluates microbially induced partial saturation (MIPS) and air injection to address these gaps and quantify their effectiveness in improving liquefaction resistance of sandy soils.

Materials and methodology

Poorly-graded liquefiable sand collected from Chidambaram, Tamil Nadu, was used in this study. Microbial desaturation

was achieved using *Pseudomonas stutzeri* (MTCC 863), a denitrifying bacterium cultured in a nitrate-rich nutrient medium to induce biogenic nitrogen gas generation (Fig. 2).

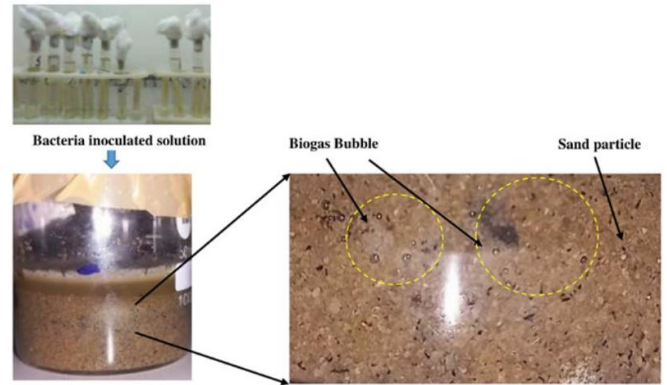


Fig. 2: A portion of biogas bubbles is shown in the picture

Undrained static and cyclic triaxial tests were performed on sand specimens at relative densities of 30–60% and effective confining pressures of 50–100 kPa. Fully-saturated specimens ($S_r = 75-95\%$) were desaturated to target saturation levels ($S_r = 75-95\%$) using either microbial denitrification or controlled air injection. Static tests assessed shear strength, strain behavior and pore pressure response, while cyclic tests evaluated cyclic resistance under stress-controlled loading ($CSR = 0.2-0.4, 1 \text{ Hz}$).

Air injection efficiency was evaluated through calibrated injection pressures ($\leq 1.7 \text{ kPa}$) to achieve uniform desaturation without inducing soil cracking. The relationship between injection pressure, B-value and degree of saturation was established. Numerical simulations using FLAC 3D with the Finn model reproduced pore pressure generation and strain response under cyclic loading, with bulk modulus adjustments accounting for partial saturation.

Gas sustainability and migration were examined using vertical and horizontal flow setups under hydrostatic and gradient conditions, demonstrating stable air/biogas retention over extended durations. A large-scale plexiglass chamber and 1-g shaking table tests validated liquefaction resistance under controlled desaturation. Finally, a prototype automated air-water injection system integrating microcontrollers and real-time feedback was developed to demonstrate scalable, in-situ IPS implementation.

Results and discussion

MIPS static triaxial tests showed that untreated loose and medium-dense sands exhibited strain-softening with near-complete pore pressure buildup ($r_u > 0.98$), whereas MIPS-treated loose sands displayed strain-hardening, $\sim 1.4\times$ higher peak strength and reduced r_u (0.30–0.46). Dense sands showed minor strength reduction due to dilation effects. Microbial desaturation shifted the instability line toward the critical state and reduced the liquefaction potential index (LPI) from 0.55 to 0.05. Biogenic gas generation was strongly influenced by nitrate concentration and temperature, with optimal activity at 37–47 °C.

Under cyclic loading, MIPS-treated specimens showed a marked increase in cyclic resistance with decreasing saturation, particularly for $S_r < 85\%$. At $S_r = 85\%$, the maximum r_u was limited to 0.05, indicating non-liquefaction behavior. Excess pore pressure evolution, stress-strain response and failure modes differed significantly between treated and untreated sands across saturation levels ($S_r = 99-91\%$), with consistent improvements observed at higher relative densities and confining pressures (Fig. 3).

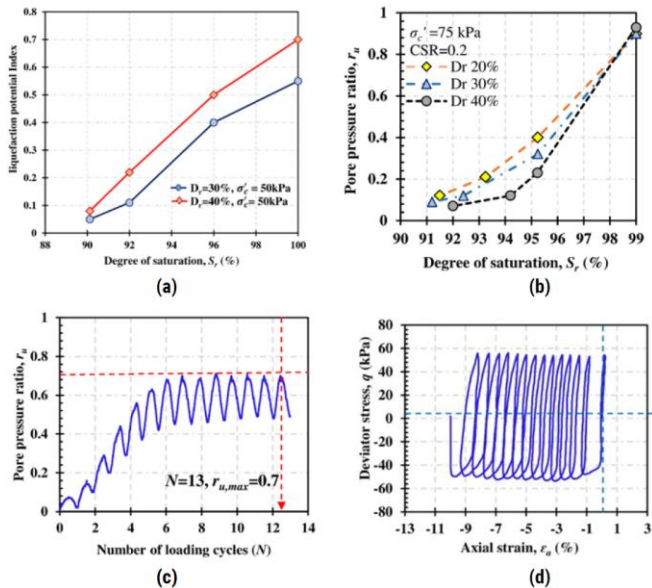


Fig.3 (a) Variation of LPI with degree of saturation (b) Variations of the excess pore pressure ratio with degree of saturation (c) excess pore pressure response (d) stress strain curve in MIPS treated sand

Direct air injection effectively reduced saturation and enhanced liquefaction resistance across all densities. Desaturated specimens exhibited increased stiffness, reduced r_u and higher CSR, with $S_r \approx 75\%$ producing the most significant gains (Fig.4). Even minor reductions in S_r increased the factor of safety against liquefaction ($\text{FOSL} > 1$) under earthquake loadings ($\text{PGA} = 0.08\text{--}0.36\text{ g}$). Optimal target saturations were identified as 75% for $D_r = 20\%$ and 80% for $D_r = 30\text{--}40\%$, accompanied by increased shear modulus and reduced damping.

Numerical simulations reproduced the experimental liquefaction response of partially saturated sands with high accuracy. At $D_r = 30\%$, fully saturated specimens liquefied ($r_u = 1$), whereas partially saturated specimens ($S_r \leq 85\%$) showed substantially reduced r_u (≤ 0.09). At $D_r = 40\%$, fully saturated specimens liquefied under lower confining pressure, while partially saturated specimens remained stable ($r_u \leq 0.11$).

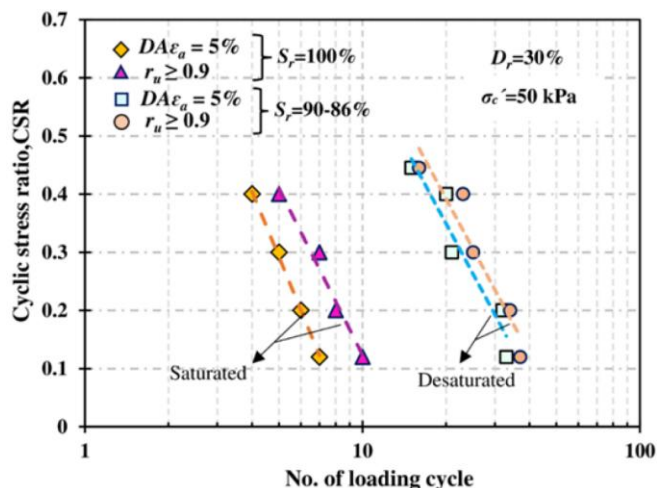


Fig.4: CSR - N under initial effective confining stress for air injected treated and untreated sands

Durability tests demonstrated effective gas retention under flow and hydrostatic conditions. Under horizontal flow, saturation increased by 4% for air injection and 2.5% for MIPS-treated samples, while vertical flow showed smaller increases

($\leq 2.5\%$) (Fig.5). Under hydrostatic conditions, saturation increased by only $\sim 0.5\%$ over 30 days. Saturation remained stable between 25–35 °C and decreased by $\sim 4\%$ at 35–45 °C, indicating enhanced gas stability at elevated temperatures.

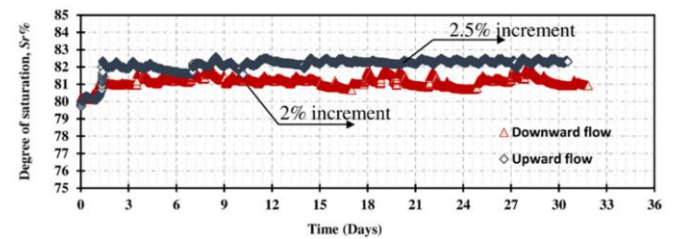


Fig.5: Variation in the degree of saturation under vertical flow conditions for air-injected sand sample

In the prototype air injection system, horizontal injection achieved superior performance with 84% spatial coverage, compared to a limited radial influence in vertical injection. Target saturation levels of $\sim 80\%$ were achieved without soil disturbance. Shaking table tests confirmed reduced excess pore pressure generation ($r_u < 0.5$), lower settlement and mitigated stiffness degradation with decreasing saturation. An automated air-water injection system with real-time sensor feedback was developed to maintain target partial saturation through controlled air-water cycling, demonstrating a scalable and field-adaptable solution for long-term liquefaction mitigation.

The above work was awarded the best PhD Research work in deep foundation engineering under DFI of India Student Awards 2025.

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Modern Slope Stability in 2026: What Really Matters?

Dr. Reginald Hammah
Director of Rocscience in Africa at Rocscience

Introduction

"Which method should I use for my limit equilibrium slope stability analysis?"

This question has been repeated in geotechnical engineering offices for several decades. And it has often yielded the answer: "It depends." While this answer is frustrating, it shows a fundamental truth about slope stability analysis – there is no single method that fits all problems.

The choice of analysis method can mean the difference between an economical design and a conservative (or, worse yet, unconservative) one. It can also mean the difference between finding true failure mechanisms or completely missing them.

Since my original presentation on this topic in Rocscience (2021), the state of slope stability analysis has evolved. Numerical methods, such as the finite element method-based shear strength reduction (FEM-SSR), have matured into a proven, effective tool that now stands alongside traditional limit equilibrium methods. New comparative studies have quantified differences between methods. Perhaps most importantly, we have gained a greater understanding of the limitations and appropriate applications of each approach. As a result, we can select slope stability methods with greater confidence.

The Challenge of No Universal Solution

An uncomfortable truth that both research and practice continue to confirm is that there is no single "best" method for all slope stability problems. This statement, which is commonly found in the literature from Morgenstern and Price (1965) through Wright (2013) to recent studies, is not an excuse. Rather, it reflects the intrinsic limitations of all slope stability analysis methods.

This article focuses on the most widely used limit equilibrium methods of slices for slope stability analysis - the Simplified Bishop, Janbu, Spencer, and generalized limit-equilibrium (GLE) formulations of the Morgenstern-Price and Sarma methods. Textbooks and comparative studies consistently identify them as the principal methods in current practice. The Ordinary (Fellenius/Swedish circle) method, although historically important as the first and simplest method of slices, is discussed only briefly because it is now rarely used.

The slope stability problem, formulated as a method of slices, is statically indeterminate. For N slices, we have more unknowns than equations available from statics (force equilibrium in two directions and moment equilibrium).

To solve this indeterminate problem, each method makes different assumptions about interslice forces – the normal and shear forces acting between adjacent slices. These assumptions are what distinguish one method from another. The interslice assumptions of the common methods are as follows:

- **Ordinary (Fellenius):** Neglects interslice forces entirely.
- **Bishop Simplified:** Considers interslice normal forces but neglects shear forces; satisfies moment and vertical force equilibrium but not horizontal force equilibrium.
- **Janbu Simplified:** Similar to Bishop, but satisfies horizontal force equilibrium instead of moment equilibrium.

- **Spencer:** Assumes constant inclination of all interslice forces.
- **Morgenstern-Price/GLE:** Assumes a function describing interslice force inclination.
- **Sarma:** Uses a quasi-Mohr-Coulomb relationship for interslice forces.

The key insight is that **no method is "exact."** All of them use assumptions to make the problem determinate. Some of them do not satisfy all the equations of equilibrium, while others do. Methods satisfying all force and moment equilibrium conditions, called rigorous or complete methods, may not be inherently more accurate; they simply make different assumptions.

The practical implication is that you must use more than one method, especially for critical projects. The real difficulty lies in determining which set of methods yields the 'best' estimate of stability for the specific problem at hand.

The next section of the article will examine the fundamental concepts of the line of thrust, tension, and convergence, which are highly useful for evaluating the performance, advantages, and disadvantages of various limit equilibrium analysis methods.

Understanding the Line of Thrust

The line of thrust remains one of the most important validity checks for rigorous methods. However, it is "sadly, often ignored in practice". This line is the locus of points where interslice forces act. Ideally, it should remain within the potential sliding mass. When it exits the boundaries or exhibits odd behaviour, the solution may be physically unacceptable even though it yields a numerical answer.

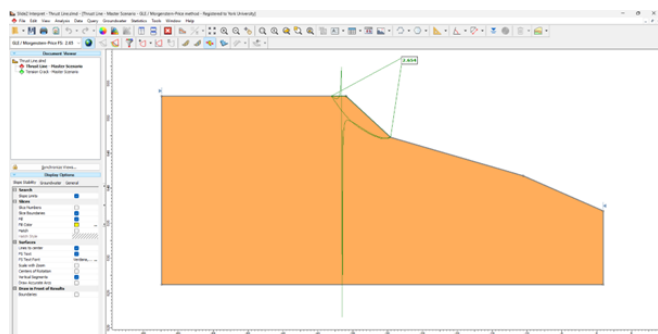


Figure 1. Line of thrust in GLE Method results

For example, in pseudo-static seismic slope stability analysis, the thrust line can exit the sliding mass when using methods that satisfy complete equilibrium. The engineer must then decide whether to accept this result, apply measures that lead the line back inside, or question whether the rigid-body assumption underlying these methods is appropriate for the problem at hand.

Tensile Interslice Forces

Rigorous methods that satisfy complete equilibrium tend to develop negative (tensile) interslice forces wherever there is a hump or kink in the potential slip surface and at the upper end of shallow surfaces (Wright, 2013; Pyke, 2017). Analysis of slopes with high-cohesion materials using rigorous limit equilibrium methods can result in tensile interslice or base forces.

USACE guidance explicitly notes that "tensile forces from cohesion" can appear at the crest in cohesive slopes, and that

these are artifacts of the analysis that typically require tension cracks or other modelling adjustments.

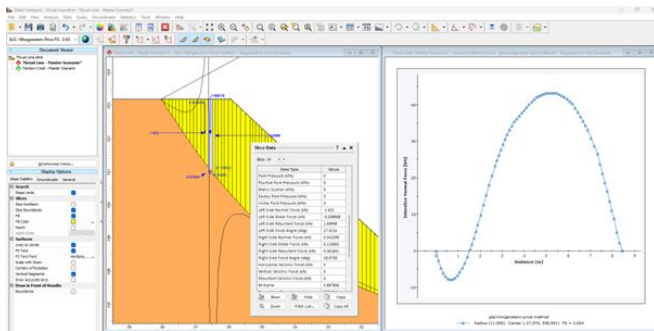


Figure 2. Interslice normal force (kN) shown in Slice Data and the graph showing Interslice normal force (kN) vs. Distance (m)

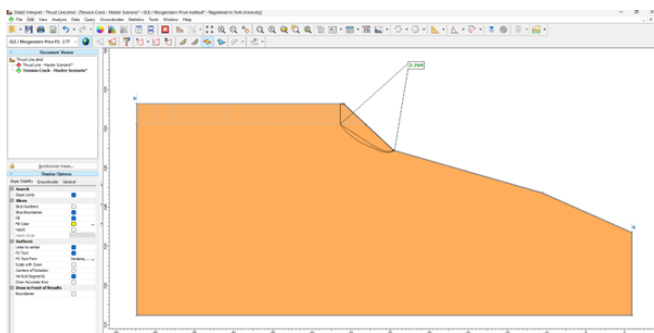


Figure 3. Critical surface after a tension crack is defined

Software documentation (e.g., Slide3) explicitly warns that where slopes exhibit high cohesion, slip surfaces through that zone may converge to solutions with tensile forces at the bases and between columns, and recommends introducing a tension crack to remove these unphysical tensile forces.

Since soil and rock masses generally have negligible tensile capacity, some experts maintain that solutions involving significant tensile forces should be rejected or modified.

The typical remedy involves inserting tension cracks. However, this raises a new question: how deep should they be? The answer often requires engineering judgment and iterative analysis; the engineer must decide whether a model with perhaps artificially deep tension cracks is realistic. (Some documentation, including Slide2's help file, outlines theoretical considerations that help establish tension crack depth.)

Convergence

Methods that satisfy complete equilibrium can experience convergence difficulties, particularly when:

- Slip surfaces have reverse slopes near the toe.
- Pore pressures are high.
- Slip surface curvature is large.

It is important to note that non-convergence is not simply a computational inconvenience; it can yield physically unacceptable results.

Updated Guidance on the Limit Equilibrium Methods

Several limit-equilibrium methods of slices are available in commercial software. They range from simple historical procedures to rigorous complete-equilibrium techniques. In this section, we briefly describe how these methods differ in their treatment of interslice forces and equilibrium conditions, and

why some are better suited than others for specific slope geometries, loading conditions, and related factors.

Bishop Simplified Method (Bishop, 1955)

The Bishop Simplified method considers interslice normal forces but neglects shear forces. It satisfies vertical force equilibrium and moment equilibrium about the centre of rotation, but does not satisfy horizontal equilibrium.

Strengths:

- Simple formulation, widely understood and trusted.
- Fast and computationally robust convergence.
- Results are typically within 5% of rigorous methods for circular surfaces (Duncan, 1996).
- Excellent as a cross-check method.

Weaknesses:

- Does not satisfy horizontal force equilibrium.
- Experiences convergence problems when the slip surface has a reverse slope near the toe.
- Not great for translational failure modes.

Nuances of the Bishop Circular vs. Non-Circular Debate

Conventional wisdom is that the Bishop Simplified Method should **be used only for circular slip surfaces**. This view is theoretically valid since Bishop's method satisfies moment equilibrium about a rotation centre by assuming normal forces on slice bases pass through this centre, which breaks down for non-circular surfaces.

Why do experts traditionally say, "circular only"?

1. **Mathematical foundation:** Fredlund et al. (1992) demonstrated that when Bishop's method is applied to non-circular surfaces, the factor of safety depends on the choice of moment point because the system has a net unbalanced horizontal force. This is especially problematic for slopes with earthquake loads or soil reinforcement.
2. **Authoritative recommendations:** Abramson et al. (2002) state that they "recommend BSM to use only for the circular shear surface analysis." Similar guidance appears in numerous textbooks and references.

Why do you see it used for non-circular surfaces anyway?

Despite the theoretical limitations described above, Bishop's method is widely used in practice for non-circular surfaces. Modern software implementations account for the fact that normal forces do not pass through the rotation centre by calculating the moment arm associated with each normal force. According to Slide2's documentation (2022): "Thus, most of the time, you get reasonable results for most noncircular surfaces".

Additionally, Bishop's computational robustness is important. The method is "virtually free from convergence problems" (Cheng & Lau, 2008), whereas rigorous approaches such as Spencer and Morgenstern-Price can struggle to converge. Research shows that, for many slope configurations, Bishop's results are typically within 5% of those of rigorous methods.

The 2026 'Consensus'

Segments of the geotechnical community have evolved from a strict "Bishop = circular only" rule to a more nuanced understanding. The insights are as follows:

- **For circular surfaces:** Bishop is excellent; it is fast, robust, and accurate, and can be confidently used.
- **For non-circular surfaces:** Bishop can serve as a cross-check but should not be used as the sole method; the Spencer, Morgenstern-Price, or Janbu can be used as the primary methods. Hong Kong practice, for example, uses Bishop alongside Morgenstern-Price for non-circular surfaces and finds that “the differences between the Bishop FoS and the Morgenstern-Price FoS are, however, small” (Shiu et al., 2007); similar results have been reported by Aryal (2006). If Bishop shows significantly different results, it may indicate convergence problems in the rigorous methods rather than Bishop being “wrong”.
- **When to absolutely avoid Bishop for non-circular analysis:** Bishop must not be applied for slopes with significant horizontal loads (seismic, tiebacks, anchors), translational sliding modes, highly irregular geometries, or when the exit angle is steeply upward.

Janbu Simplified and Corrected Methods (Janbu, 1954; Janbu et. al., 1956)

The Janbu Simplified and Corrected methods have the following strengths and weaknesses:

Strengths:

- Handle both circular and non-circular surfaces effectively.
- Fast computation.
- The correction factor (f_0) improves accuracy by 5-12%.
- More flexible than Bishop for complicated geometries.

Limitations:

- Do not satisfy moment equilibrium.
- Experience convergence problems with high-curvature or high-pore-pressure slopes.
- Typically underestimate the factor of safety compared to rigorous methods for circular surfaces.
- The correction factor depends on the depth/length ratio and requires judgment when applying.

Recent insights:

Studies (Fredlund & Krahn, 1977; Duncan, 1996; Aryal, 2006) show that the Janbu Corrected method yields results close to those of rigorous methods for non-circular surfaces. However, the approach may be too simplistic for complicated lithologies.

Spencer Method (Spencer, 1967)

The Spencer method is best for general use, seismic analysis, and reinforced slopes. Its strengths and limitations are as follows:

Strengths:

- Simplest rigorous (complete equilibrium) method.
- Assumes constant angle of interslice forces (parallel forces).
- Handles horizontal/inclined loads well (tiebacks, anchors).
- Applicable to virtually all slopes.
- Generally reliable convergence.

Limitations:

- Convergence problems during critical surface search.
- May require tension-crack assumptions to achieve an acceptable line of thrust.

Recent insights:

The Spencer method is recommended for most applications. Studies comparing it with the Morgenstern-Price method show differences of typically less than 2% when both converge. Spencer’s constant interslice force angle assumption, while simpler than Morgenstern-Price’s variable function, rarely causes significant errors for practical problems.

The recommendation is to use Spencer for final design, seismic/dynamic loads, and reinforced slopes when accurate internal force distribution matters. **Users may need to** verify the line of thrust.

GLE / Morgenstern-Price Method (Morgenstern & Price, 1965; Fredlund & Krahn, 1977)

The GLE / Morgenstern-Price method is best for complex problems and when control over the interslice force function is desired. It has the following pros and cons:

Strengths:

- Users can specify the interslice force function (half-sine, trapezoidal, etc.) (although practitioners rarely do this).
- Well-established and widely implemented.

Limitations:

- Different interslice force functions can influence results.
- May require tension-crack assumptions to achieve an acceptable line of thrust.
- More complex than Spencer.
- Users must verify that reasonable lines of thrust are achieved.

Recent insights:

Research by Fredlund and Krahn (1977), Duncan (1996) and others has confirmed that factors of safety are generally insensitive to the choice of interslice force function in practical problems, with differences typically less than 5%. This addresses a long-standing concern about the method. However, for external loads (anchors, point loads), the moment equilibrium factor of safety becomes more sensitive.

Sarma Method (Sarma, 1973)

The Sarma method is best suited to slopes with discontinuities (including rock slopes) and seismic analysis. It has the following strengths and weaknesses:

Strengths:

- Handles non-vertical slice boundaries (the 1979 extension).
- Slice properties can be set independently, which allows modelling of discontinuities and faults.
- Originally developed for seismic analysis (critical acceleration approach).
- Satisfies complete equilibrium.
- Is fundamentally different from the other methods by relating interslice forces through a shear strength equation applied along the interslice boundaries themselves, not just to the base (slip surface). This means the method

treats each interslice boundary as a potential failure surface where shear strength is being mobilized.

Limitations:

- More complex than the other methods.
- Requires all normal forces on block bases and sides to be positive.
- Less widely implemented in commercial software.
- Steeper learning curve.

Recent insights:

Comparative studies (Sun et al., 2011) using discontinuous deformation analysis (DDA) show that the Sarma method performs well for jointed rock slopes (when geological structures, such as faults, bedding planes, and joints, control failure mechanisms). However, it should be noted that the method assumes simultaneous failure of all internal discontinuities and the basal surface at the same safety factor. In reality, progressive failure may mean that some joints are fully mobilized while others are not.

Modern Search Algorithms and Their Impact on LEM Accuracy

Regardless of which limit equilibrium method is selected, Spencer, GLE, Morgenstern-Price, or any other, the accuracy of a slope stability analysis hinges crucially on whether the search has actually located the most critical slip surface. An analysis, for example, using a rigorous method, can still produce misleading results if the search is inadequate. Deficiencies in the slip-surface search are not inherent limitations of LEM analysis.

From Grid Search to Global Optimization

Early LEM implementations relied on grid-and-radius searches for circular surfaces and user-defined trial surfaces for non-circular problems, which were effective for simple homogeneous slopes. However, they can fail to identify critical failure modes in complex geometries (such as those with weak layers, anisotropic materials, or irregular stratigraphy). Modern software has progressively introduced global optimization algorithms. These algorithms, including Simulated Annealing, Cuckoo Search, and Particle Swarm Optimization (PSO), explore the search space far more efficiently and with minimal user input.

Surface Altering Optimization

An important innovation in LEM search for critical failure surfaces is Surface Altering Optimization (SAO). It is a derivative-free local optimization method that improves the geometry of slip surfaces found by global search algorithms. SAO converts an initial surface (e.g., circular or elliptical) into a spline approximation defined by a grid of control points. It then systematically adjusts those control points to minimize the factor of safety. When combined with a global search method, SAO consistently yields lower factors of safety than the global search method alone, particularly for models with thin, weak layers and anisotropic conditions.

Additional Search Innovations

Several other algorithms have been recently developed to improve limit equilibrium analysis. These include improved algorithms for handling weak layers, multi-modal optimization and approaches for managing both convex and concave slip surfaces in non-circular analysis.

Traditional searches only find a single global minimum. This approach may miss other important failure modes. For ex-

ample, open pit slopes, comprising multiple benches and material zones, can exhibit several distinct failure modes. Multi-Modal Optimization (MMO) can identify multiple critical failure surfaces simultaneously.

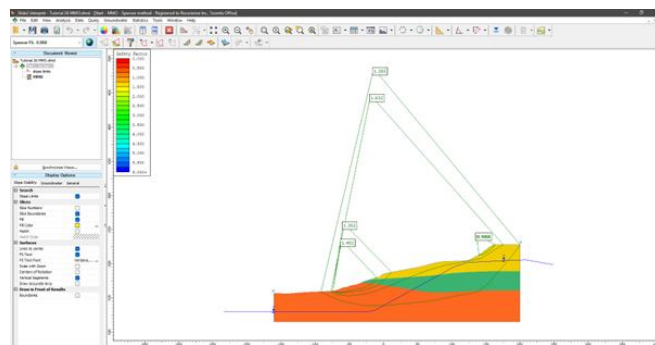


Figure 3. Multiple slip surfaces of local mins

The search for non-circular failure modes encounters both convex and concave slip surface geometries. Concave surfaces naturally form at slope toes, while convex segments can develop where slip surfaces follow the upper boundary of an inclined weak layer; circular methods cannot capture this situation. Modern implementations allow users to control the permissible convex angles during surface generation, ensuring that physically meaningful surfaces are explored while kinematically inadmissible mechanisms are eliminated.

Lastly, some new search algorithms cross-check rigorous results against simplified methods. For example, they run Bishop or Janbu Simplified analysis alongside Spencer or GLE, which provides a rapid diagnostic. If Bishop or Janbu results show a significantly different factor of safety from the rigorous methods, it may indicate convergence problems in Spencer or GLE rather than a true difference in stability.

The FEM with Shear Strength Reduction (Griffiths & Lane, 1999; Hammah, 2005)

Over the past 20 years or more, the finite element method (FEM) has become a reliable technique for determining the safety factor of slopes. This section briefly describes the method and its role in contemporary slope stability analysis.

A Method That Has “Passed the Healthy Skepticism Test”

The finite element method with shear strength reduction (FEM-SSR) has remarkably transformed slope stability analysis. What was formerly viewed as a research tool calling for specialized expertise is now recognized as a “robust alternative to limit equilibrium slope stability analysis” that has “passed the healthy skepticism test with flying colours” (Rocscience, 2022).

How FEM-SSR Works

The concept is simple: **systematically reduce the shear strength envelope of all materials by a strength reduction factor (SRF), and compute FEM models until failure occurs.** Failure is typically defined by non-convergence, i.e., when no stress distribution can satisfy global equilibrium given the failure criteria (material strengths).

This technique offers a fundamental advantage: **it does not require a priori assumptions** about the shape or location of failure surfaces. The failure mechanism arises natively in the model zones where shear strength is insufficient to withstand the applied stresses.

When FEM-SSR can be better than Limit Equilibrium

The consensus in the last few years is that FEM-SSR is mandatory for:

1. Progressive failure analysis: When parts of the slope may fail sequentially.
2. Strain softening materials: Post-peak strength reduction affects stability.
3. Consolidation effects: Time-dependent pore pressure changes matter.
4. Complex coupled processes: Hydro-mechanical interaction, seepage with deformation.
5. No obvious failure mechanism: Unknown slip surface location, shape, or failure mechanism (e.g., flexural or direct toppling).
6. Reinforcement stress analysis: Need to calculate bending moments and axial forces in structural elements.
7. Deformation-sensitive structures: Adjacent buildings, utilities where displacement matters.

We must add that, due to recent innovations to limit equilibrium analysis, the differences between its outcomes and those of FEM-SSR analysis for rotational, translational mechanisms, or their combination, have narrowed significantly.

Limitations

FEM-SSR is not always better, though. It has the following drawbacks:

1. Requires more input parameters: Stiffness, stress-strain relationships, and dilatancy.
2. Computationally more intensive: Longer run times, larger models.
3. Steeper learning curve: Requires expertise in constitutive modelling and meshing.
4. Calibration challenges: Deformation properties are harder to determine than strength.
5. Multiple equilibrium paths: Results can depend on loading sequence and mesh refinement.

Practical Recommendations

Current best practice calls for using both LEM methods and FEM-SSR to complement each other.

1. LEM for preliminary screening: Fast, code-compliant, established practice.
2. FEM for complex cases: Progressive failure, coupled processes, deformation-critical situations.
3. Cross-validation: When both methods give similar results, confidence increases.
4. Investigation when divergent: Significant differences (>15%) warrant examining assumptions.

The 3D Question

For 3D analysis, the choice of limit equilibrium method is actually simpler than 2D; only four methods are reliably available: Bishop, Janbu, Spencer, and GLE-Morgenstern-Price.

Final Thoughts

The 2026 landscape for slope stability analysis offers more tools than ever, but it also demands greater judgment. Here are the key takeaways from the research and discussions in this article:

On Limit Equilibrium Methods

1. No universal method exists. Method selection depends on failure surface shape, geology, loading, and project criticality.
2. "Rigorous" ≠ "more accurate". Methods satisfying complete equilibrium make different assumptions than simplified methods and may not be automatically more correct.
3. Bishop continues to be relevant (particularly for circular surfaces), even 70 years after its introduction. It can be used for non-circular surfaces as a cross-check in 2026. The strict "circular only" rule has softened with modern software corrections and a better understanding of when it matters.
4. Janbu is efficient and robust for non-circular failure surfaces and layered slopes and is great as a preliminary or companion method: it handles complex geometries and often converges where rigorous methods experience difficulties.
5. Spencer and GLE/Morgenstern-Price are preferred for more rigorous analyses, but examine for convergence problems, tension and the line of thrust.
6. Sarma deserves more use for rock slopes, i.e., when discontinuities control failure.
7. Always check the validity of your results: line of thrust and tension (for the rigorous methods), and convergence. Software does not automatically ensure physical acceptability.

On Finite Element Methods

1. FEM-SSR has matured into a production tool. It is no longer only for research or exceptional cases.
2. Use FEM-SSR when deformation matters, progressive failure is possible, pore pressures are complex, or you need to model coupled processes.
3. FEM does not replace LEM in routine work. A simple failure still gets a good answer from Bishop in seconds.
4. The 'best' analyses use both LEM and FEM for critical projects; the combination utilizes the speed of LEM and the sophistication of FEM.

The question "Which method should I use?" still depends on context, but we now have a better framework for answering it. The art of slope stability analysis is not in finding "the answer" but rather in understanding which assumptions are appropriate for your problem, which methods embody those assumptions, and how sensitive your results are to uncertainty.

Regardless of which method you choose, **always verify the physical reasonableness of results**. As Whitman and Bailey warned in 1967 (and remains true in 2026): "The use of sophisticated methods together with a computer does not free the engineer from making a judgment concerning the reasonableness of a solution". **Engineering judgment cannot be automated**, and software is a tool and not a substitute for insight.

Choose your methods wisely and check your results carefully!

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How Unsaturated Soils Shape the Stability of Tailings Dams – and Why You Should Care

Sina Moallemi, Geotechnical Product Manager, Arsan Jamei, Geomechanics FE Specialist

When a tailings dam fails, the consequences are catastrophic – entire communities can be displaced, ecosystems destroyed, and billions of dollars lost. Yet many stability analyses overlook a critical factor that could mean the difference between adequate safety margins and disaster: the behaviour of unsaturated soils.

Early developments in soil mechanics focused primarily on saturated soils and classical design frameworks. They were built on the concept of effective stress, which combines total stress and pore water pressure. Although this framework is appropriate for fully saturated soils (those below the water table), it is often applied to partially saturated primarily for convenience.

In unsaturated soils, matric suction above the phreatic surface can contribute to shear strength through its influence on the effective stress state. Classical saturated soil mechanics commonly ignored negative pore water pressures when applying Terzaghi's effective stress principle; the profession was uneasy about their direct inclusion, as it could, in theory, increase effective stress beyond total stress. This practice is still widely accepted in geotechnical engineering and generally leads to conservative stability assessments.

However, experimental and theoretical work by Fredlund, Vanapalli [1,2], among others, demonstrated that in partially saturated soils, matric suction influences soil behavior in a manner that depends on the degree of saturation and the soil water characteristic curve. In unsaturated soil mechanics, the influence of matric suction can be incorporated either through modified effective stress formulations in which its contribution is scaled by the degree of saturation using soil water characteristic curves, or through direct inclusion in the shear strength formulation. Both approaches allow suction effects to be represented in a physically meaningful way and lead to more realistic stability assessments, particularly for short term conditions in which unsaturated zones persist before significant dissipation of suction occurs.

These effects are especially important for geotechnical structures such as tailings storage facilities, earth dams, levees, and highway embankments with large and persistent unsaturated zones. In such systems, suction can increase the factor of safety and modify both the depth and shape of the critical failure surface. However, because this additional state-dependent strength is highly sensitive to changes in seepage and pore pressure conditions, unsaturated soil mechanics is still overlooked in practical stability analyses.

This article uses a tailings dam case study to demonstrate how unsaturated soil mechanics formulations implemented in [RS2](#) and [RS3](#) can capture matric suction effects and yield more realistic stability assessments than traditional saturated analyses.

Theoretical Background: Approaches to Modelling Unsaturated Soil Behaviour

There are two widely used approaches for incorporating unsaturated soil behaviour in finite element analyses: modifying the effective stress framework to account for matric suction, referred to here as the Single Effective Stress approach, and directly incorporating suction into the shear strength criterion, referred to as the Shear Strength Modification approach.

These approaches are complementary and represent different physical interpretations of unsaturated soil mechanics.

Approach 1: Single Effective Stress

The classical effective stress principle, introduced by Terzaghi for saturated soils, can be extended to unsaturated conditions through modified formulations that account for air and water pressures in the pores. A widely used extension is based on the Bishop effective stress concept [3], in which a saturation-dependent parameter scales the contribution of matric suction to effective stress. The effective stress may be expressed as:

$$\sigma' = \sigma - \alpha \chi(S_r) p^w$$

where:

- σ' is the effective stress
- σ is the total stress
- α is the Biot coefficient, a material parameter ranging from 0 to 1 and typically close to 1 for most soils
- $\chi(S_r)$ is the surface fraction coefficient, expressed as a function of the degree of saturation
- p^w is the pore water pressure, which is negative under unsaturated conditions and represents matric suction

The surface fraction coefficient $\chi(S_r)$ describes the proportion of interparticle contacts influenced by pore water pressure through a function of saturation state. Multiple formulations for $\chi(S_r)$ have been proposed in the literature, each reflecting different conceptual models of water distribution within the soil-pore space. For example, the original *Bishop* formulation assumes $\chi = S_r$, whereas the formulation proposed by *Bolzon* et al. approximates this parameter using the effective degree of saturation [4]. The details of all available formulas are provided [here](#).

The implementation in RS2 and RS3 allows engineers to select one of these formulations based on material characterization studies or laboratory measurements of soil water retention curves, thereby providing modelling flexibility across different soil types and saturation regimes. This approach directly modifies the effective stress, which then governs the soil's strength through the assigned constitutive model.

Approach 2: Shear Strength Modification

An alternative and complementary approach treats matric suction as a direct contributor to soil shear strength, without modifying effective stress. This phenomenological approach recognizes that matric suction generates capillary forces that resist shear deformation. In RS2 and RS3, two formulations are available for use within the Mohr-Coulomb shear strength framework.

Fredlund and Rahardjo Formulation:

A widely adopted simplified formulation directly incorporates suction into the shear strength expression by extending the cohesion component as:

$$\tau = c' + (u_a - u_w) \tan(\phi^b) + (\sigma_n - u_a) \tan(\phi')$$

where:

- c' is the effective cohesion
- σ_n is the total normal stress
- u_a is the pore air pressure
- u_w is the pore water pressure
- ϕ' is the effective angle of internal friction
- ϕ^b is the angle defining the rate of increase in shear strength with matric suction

The term $(u_a - u_w)$ represents matric suction. The parameter ϕ^b is typically smaller than ϕ' but greater than zero, reflecting

the reduced efficiency of suction in mobilizing shear strength compared to normal stress. This formulation is intuitive and practical, as it directly increases shear strength in proportion to the matric suction present.

Vanapalli et al. Formulation:

A more advanced formulation incorporates the influence of the degree of saturation on suction's contribution to shear strength, expressed as:

$$\tau = c' + (\sigma - u_a) \tan(\phi') + (u_a - u_w) [\tan(\phi') \{ (S_r - S_{re}) / (100 - S_{re}) \}]$$

where S_r is the degree of saturation, and S_{re} is the residual degree of saturation. This formulation reflects the reduction in suction-induced strength as the soil approaches residual saturation, more realistically representing the physics of unsaturated behaviour. The choice between these approaches depends on the specific application, the available material characterization data, and the saturation range of interest. Both approaches are implemented in RS3 and RS2, allowing practitioners to select the methodology best suited to their project requirements.

Problem Description: Tailing Dam Stability Analysis

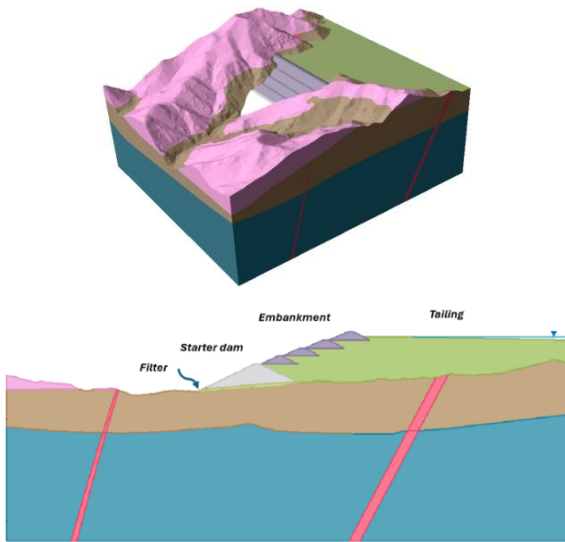


Figure 1. 3D tailings dam model and corresponding 2D cross section of the dam regions

For this analysis, the Fredlund formulation was adopted to account for unsaturated soil behaviour by incorporating matric suction directly into the shear strength of partially saturated regions.

The material properties assigned to the different zones are summarized in the table below:

Material Zone	Young's Modulus	γ (kN/m ³)	c'	ϕ'
Starter Dam	60 MPa	20	10 kPa	35°
Tailings	14.5 MPa	18	4 kPa	26.5°
Embankments	45 MPa	21	25 kPa	30°

Results: Impact of Unsaturated Soil Mechanics on Factor of Safety

The stability analysis was performed using the shear strength reduction (SSR) method in both RS2 and RS3 to identify the critical failure mechanism. Two analysis scenarios were considered. In the first scenario, the contribution of unsaturated soil strength was neglected, whereas in the second, it was incorporated using the Fredlund formulation.

Figure 2 shows the 3D displacement pattern after failure. In addition, the relative displacement patterns at the critical cross-section in the 3D model and the corresponding results from the 2D analysis are presented in Figures 3 and 4, respectively.

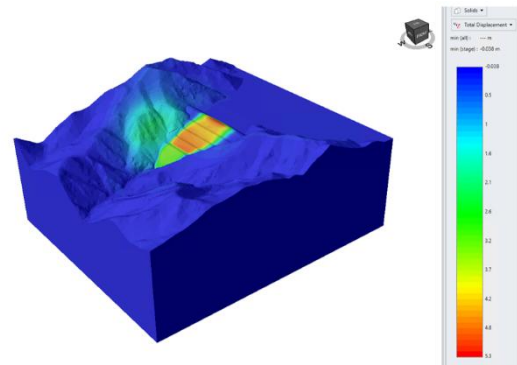


Figure 2. Displacement pattern at SRF = 2.3, after the failure has occurred

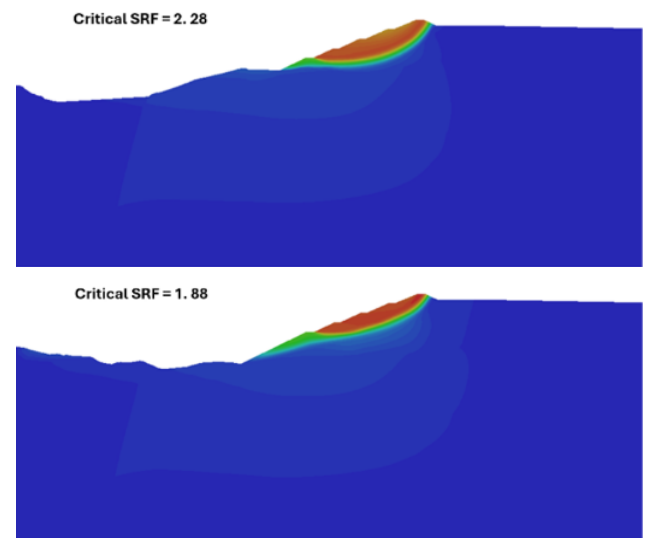


Figure 3. Displacement pattern after the failure in the critical cross section of the 3D model, (Left) by considering the effect of unsaturated soil, (Right) ignoring the unsaturated soil strength

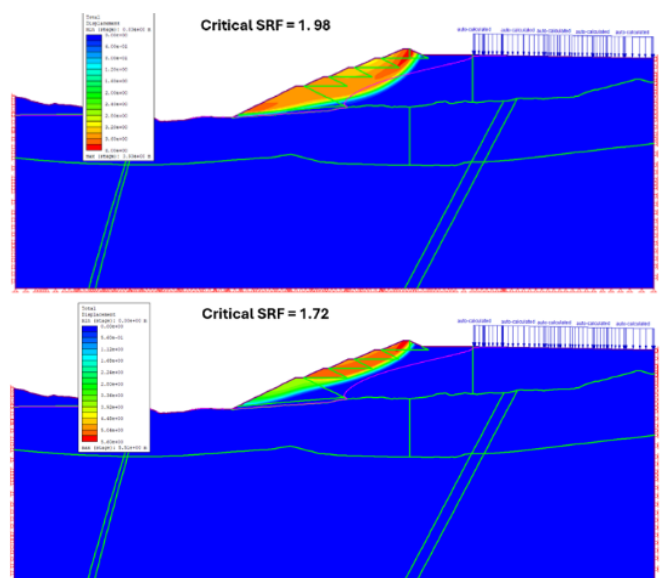


Figure 4. Displacement pattern in the 2D model after the failure, (Left) by considering the effect of unsaturated soil, (Right) ignoring the unsaturated soil strength

Figure 5 shows the pressure head distribution and the water table location in the 2D model. The results indicate that water flows through the filter beneath the starter dam, generating negative pore water pressures in the region near the dam raises.

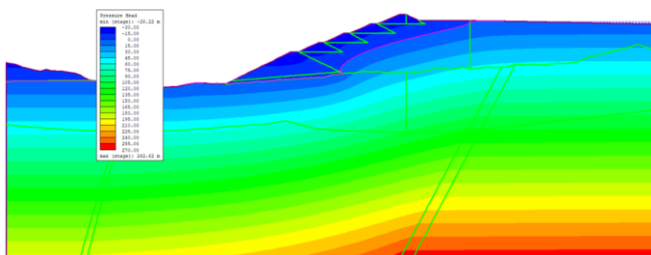


Figure 5. Pressure head and water table in the 2D model

A summary of the calculated critical SRFs for both the 2D and 3D analyses is provided in the table below:

Analysis Scenario	3D	2D
Without unsaturated considerations	1.88	1.72
With unsaturated soil mechanics	2.28	1.98

In both 2D and 3D analyses, a significant increase in critical SRF, on the order of 15-18 percent, is observed when unsaturated soil mechanics is considered. This increase represents the direct contribution of matric suction within the partially saturated tailings to overall slope stability.

Comparison of the failure mechanisms in both the 2D and 3D scenarios reveals a fundamental difference in the predicted slip surfaces. **When unsaturated soil effects are neglected**, the critical failure surface is **relatively shallow**, initiating near the slope face and propagating into zones where lower shear strength is mobilized. This behaviour corresponds to a conservative interpretation of soil behaviour.

When unsaturated soil mechanics is included, the critical slip surface extends **deeper** into the soil mass, mobilizing a larger volume of material to resist shear deformation. This response reflects a realistic contribution of matric suction to strength within the partially saturated zone. The combined effect of increased shear strength along the failure surface and deeper failure mechanisms results in higher critical strength reduction factors.

Although both the 2D and 3D analyses exhibit the same overall trend, the absolute values of the critical SRFs differ. The 3D model captures the dam's true three-dimensional geometry and the associated confinement along the dam axis, allowing additional resisting shear stresses to develop along the flanks and abutments. In contrast, the 2D analysis assumes plane strain and neglects these effects, which results in a more conservative estimate of stability.

Conclusion

The analysis presented in this article demonstrates that unsaturated soil mechanics plays an important role in modern geotechnical engineering practice, particularly for earthen structures such as dams, levees, and embankments that feature large zones of partial saturation.

For structures with factors of safety near acceptable design limits, accounting for unsaturated soil behaviour can significantly influence stability assessments. In such cases, the resulting increase in calculated stability may shift a design from marginal to clearly acceptable, potentially reducing the need for remedial measures such as additional buttressing, slope flattening, or staged construction.

Both RS2 and RS3 include comprehensive capabilities for modelling unsaturated soil behaviour. They incorporate multiple formulations of effective stress (e.g., Bishop, Bolzon, Khalili) as well as direct suction-based shear-strength approaches (Fredlund and Vanapalli methods). When used appropriately, these tools can provide engineers with a robust framework for producing accurate, economical, and defensible positions.

The key takeaway is this: while conservative assumptions have their place in engineering, overlooking the well-established physics of unsaturated soil behaviour may lead to unnecessarily conservative designs that inflate costs without proportional safety benefits — or worse, may fail to capture critical behaviour under changing conditions. As the profession continues to advance, incorporating unsaturated soil mechanics into routine stability analyses should become standard practice rather than the exception.

The tools are available. The theory is sound. The question is whether we will use them to their full potential.

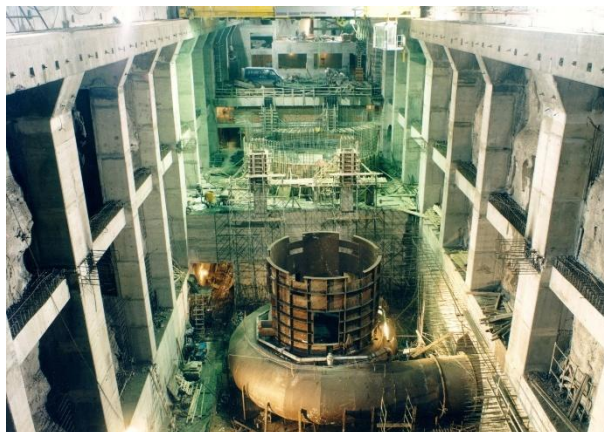
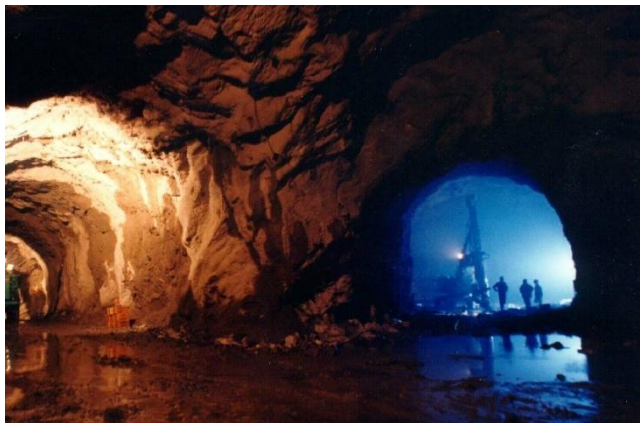
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(ROCNEWS | FEBRUARY 2026 / ROCSCIENCE, Published on: Feb 11, 2026 Updated on: Feb 24, 2026, <https://www.rocscience.com/learning/how-unsaturated-soils-shape-the-stability-of-tailings-dams-and-why-you-should-care>)

Honoring the pioneers of hydropower in Greece

Archival photos from Thissavros HEP/PPC S.A,
one of the first two pump storage plants in
Greece



Ανάρτηση Σοφίας Σιάχου στο LinkedIn.

[Sofia Siachou • Senior Energy and EPC Professional, Hydro-power/Pump Storage deep Expertise, Full cycle](#)

Qanat Water Tunnels



This is a qanat, one of the most durable hydraulic engineering structures ever built, developed in what is now Iran and still in use today. A line of holes marching across a desert, evenly spaced, stubbornly straight, and quietly ancient.

A qanat is an underground water-supply system that moves groundwater over long distances with gravity only.

Some have operated continuously for close to three thousand years, surviving empires, invasions, droughts, and neglect.

The idea is simple.

A gently sloping tunnel is driven from higher ground into an aquifer, allowing water to flow under gravity to the surface downstream.

Those holes visible at the surface are not wells in the usual sense.

They are vertical shafts, spaced every twenty to fifty metres, used to remove spoil during construction and later to ventilate and maintain the tunnel.

The slope is critical.

Too steep and the tunnel erodes or collapses, too shallow and the water stalls, so builders worked to gradients of only a few millimetres per metre over distances that could exceed tens of kilometres.

Because the channel is underground, evaporation losses are almost zero.

Water temperature remains stable, algae growth is limited, and contamination risk is lower than in open canals.

One of the most impressive features is the flow's stability.

A qanat responds slowly to rainfall variation, smoothing out wet and dry years in a way that many modern surface systems struggle to match when maintenance declines.

It is also remarkably resilient.

Floods pass overhead without destroying it, and cutting off a qanat deliberately requires collapsing long sections of tunnel rather than damaging a single visible structure.

Unlike pumped systems, energy input is front-loaded.

Once built, gravity does the work, which made these systems viable long before electricity or engines.

Water is usually used only after it emerges at the outlet.

Upstream sections remain untouched, protected, and hidden, which helped preserve both water quality and infrastructure for generations.

It is slow engineering, but durable.

Many still run today, quietly supplying villages that grew around them centuries ago.

(<https://mennoqazendam.substack.com/p/built-072026>)

Kölnbrein Dam Outlet



Since the mid 1990s, the reservoir has operated at full level.

https://www.linkedin.com/posts/mennogazendam_the-bottom-outlet-of-the-k%C3%B6lnbrein-dam-in-ugcPost-7428737267973685249--H-O

[Menno Gazendam. View my blog](#)

The bottom outlet of the Kölnbrein Dam in full action. At max reservoir level its discharge is about 70 m³ per second. Under roughly 200 m of hydraulic head, the theoretical jet velocities approach 63 m per second. (although real values are lower once friction and valve losses are accounted for.)

At 200 m high, Kölnbrein is the tallest dam in Austria, holding back roughly 205 million m³ of water high in the Alps.

That corresponds to about 205 million tonnes of water pressing against a double curvature concrete arch.

This outlet is an operating device designed to lower the reservoir in an emergency or during maintenance and testing.

It is not intended for routine sediment scour, and its capacity reflects a philosophy of controlled drawdown rather than rapid emptying.

As the water level drops, the available head reduces and the flow decreases accordingly.

For a large arch dam, rapid drawdown introduces structural and geotechnical considerations.

Differential pressures change, stress redistribution occurs through the arch into the abutments, and upstream slopes can become destabilised if pore pressures do not dissipate in step with the reservoir level.

Hydraulically, the outlet works operate under very high pressure.

Conduits, valves and energy dissipation structures must withstand extreme velocities while preventing cavitation, often managed via aeration, which can erode steel and concrete surfaces within a short time if not properly controlled.

Kölnbrein is a double curvature arch dam, meaning it transfers water load laterally into the valley flanks rather than relying primarily on mass as a gravity dam.

Water level management is therefore directly linked to structural behaviour.

During the first filling from 1978 to 1979, unexpectedly high uplift pressures developed at the upstream heel.

Cracking and seepage occurred because foundation conditions allowed water to bypass parts of the original grout curtain.

The remediation programme lasted more than a decade. It included grout curtain reinforcement and the construction of a major downstream support structure fitted with more than 600 neoprene load transfer elements to redistribute forces and accommodate deformation.

Σαντορίνη – Ένα χρόνο μετά: Μύθοι και αλήθειες για τη σεισμική κρίση

Τι προκάλεσε την κατά ριπάς σεισμικότητα - Οι απαντήσεις που έδωσαν οι επιστήμονες σε ημερίδα



Κάποιοι έκαναν λόγο για επερχόμενες εκρήξεις ηφαιστειών, άλλοι για σεισμούς μεγέθους 6,5 ρίχτερ, ακόμη και για... εξαφάνιση του νησιού στα πιο ακραία σενάρια. Η τοπική κοινωνία βίωνε τον τρόμο και τα βλέμματα όλων ήταν στραμμένα με αγωνία στη **Σαντορίνη**. Η πρωτοφανής σεισμική έξαρση βρισκόταν σε εξέλιξη και όλα τα ενδεχόμενα ήταν ανοιχτά. Ακριβώς έναν χρόνο μετά, οι ειδικοί δίνουν τις απαντήσεις τους για όσα συνέβησαν τότε καταρρίπτοντας μύθους και φωτίζοντας αλήθειες για ένα φαινόμενο που συνεχίζει να απασχολεί τη διεθνή επιστημονική κοινότητα.

Όλα αυτά σε μια ημερίδα που πραγματοποιήθηκε χθες στο αμφιθέατρο του Γεωδυναμικού Ινστιτούτου Αθηνών, με θέμα τη Σεισμοηφαιστειακή Κρίση της Σαντορίνης και τη συμμετοχή επιστημόνων από τις αρμόδιες επιτροπές Εκτίμησης Σεισμικού Κινδύνου και Παρακολούθησης του Ελληνικού Ηφαιστειακού Τόξου, που ήταν αρμόδιες για τη διαχείριση της κρίσης.

«Αυτό που συνέβη στη Σαντορίνη ήταν μια εξαιρετικά σπάνια παγκοσμίως σεισμική κρίση και ήταν η συνέχεια μιας ηφαιστειακής κρίσης που είχε ξεκινήσει στο νησί από το καλοκαίρι», επεσήμανε ο διευθυντής του Γεωδυναμικού Ινστιτούτου Βασίλης Καραστάθης. Είναι ενδεικτικό ότι, ενώ το 2024 σε ολόκληρη την επικράτεια είχαμε 90 σεισμούς μεγέθους άνω των 4 ρίχτερ, μέσα σε 10 μέρες στη Σαντορίνη – από τις 2 ως τις 12 Φεβρουαρίου 2025 – είχαμε 216 σεισμούς τέτοιου μεγέθους. Από τις 20 Ιανουαρίου 2025, όταν ξεκίνησε η σεισμική διέγερση στην περιοχή, μέχρι το τέλος Ιουνίου 2025 στη Σαντορίνη καταγράφηκαν 21.150 σεισμικές δονήσεις... Οπως επεσήμανε ο Β. Καραστάθης, «είχαμε σεισμικότητα κατά ριπάς. Φτάσαμε τους 53 σεισμούς μέσα σε μία ώρα, δηλαδή υπήρχαν ώρες που είχαμε ανά ένα λεπτό αισθητό σεισμό στην περιοχή...».

Η εδαφική παραμόρφωση στην περιοχή

Όπως επεσήμανε από την πλευρά του ο **Κώστας Παπαζάχος**, καθηγητής Σεισμολογίας στο ΑΠΘ και πρόεδρος του Ινστιτούτου Μελέτης και Παρακολούθησης Ηφαιστείου Σαντορίνης, η εδαφική παραμόρφωση στην περιοχή ήταν πολύ σημαντική – με τον ρυθμό μετατόπισης του νησιού να εκτοξεύεται στο ένα μέτρο κατ' έτος – και συνεχίστηκε, μειούμενη, μέχρι και τον Δεκέμβριο του 2025.

Ο Κ. Παπαζάχος αναφέρθηκε στην τεράστια σημασία που έχει

η παρακολούθηση των ηφαιστειών, ακόμη και σε περιόδους φαινομενικής ησυχίας, και σημείωσε πως με τη δουλειά που έχει παραχθεί θα μπορούσαν να καταρτιστούν μελλοντικά σενάρια κατανομής βλαβών στο νησί για την περίπτωση νέων φαινομένων.

Ο πρόεδρος του ΟΑΣΠ Ευθύμης Λέκκας αναφέρθηκε αναλυτικά στον κίνδυνο κατολισθήσεων στη Σαντορίνη και σημείωσε ότι από το φθινόπωρο και μετά θα ξεκινήσουν έργα ύψους 15 εκατ. ευρώ στο Παλιό Λιμάνι, στο Αμμούδι, στην Αρμένη, στον Κόρφο και έργα συντήρησης στον Αθηνιό, ενώ στα υποθαλάσσια ρήγματα στην περιοχή Σαντορίνης – Αμοργού και στον ρόλο τους στη σεισμική – μαγματική κρίση του 2025 αναφέρθηκε ο Δημήτρης Σακελλαρίου, διευθυντής Ερευνών στο Ινστιτούτο Ωκεανογραφίας του ΕΛΚΕΘΕ.

Δέκα ερωτοαπαντήσεις

Το προφίλ της σεισμικής κρίσης προκύπτει μέσα από δέκα ερωτοαπαντήσεις που παρέθεσε ο διευθυντής του Γεωδυναμικού Ινστιτούτου:

Ηταν σμήνος σεισμών ή τυπικές προσεισμικές και μετασεισμικές ακολουθίες;

Ηταν σμήνος σεισμών, όπως είχε επισημάνει από την αρχή το Γεωδυναμικό Ινστιτούτο, δηλαδή μια σειρά σεισμών παρόμοιου μεγέθους χωρίς να υπάρχει εμφανής κύριος.

Ηταν τεκτονικοί ή ηφαιστειακοί οι σεισμοί που συνέβησαν στη Σαντορίνη;

Ηταν στη συντριπτική τους πλειονότητα τεκτονικοί σεισμοί, δηλαδή το 70%-76% αυτών προερχόταν από τεκτονικές δομές, ενώ λίγοι είχαν ισοτροπική συνιστώσα. Επίσης, υπήρχαν λίγοι χαμηλόσυχνι σεισμοί που δημιουργούνται από την κίνηση του μάγματος. Αυτό μας κάνει να μιλάμε για τεκτονο-μαγματική ακολουθία.

Τελικά τι προκάλεσε τη σεισμικότητα στην περιοχή;

Η ενεργοποίηση σεισμικών ρηγμάτων έπειτα από διείσδυση μάγματος – η οποία επιβεβαιώνεται και από τη μεγάλη ταχύτητα μετακίνησης της σεισμικότητας – σε συνδυασμό με την κυκλοφορία μαγματικών ρευστών.

Οι σεισμοί εκδηλώνονταν στην επιφάνεια;

Όχι. Σε βάθη 5 έως 15 χιλιομέτρων.

Πότε ξεκίνησε η ύφεση του φαινομένου;

Στις 12-13 Φεβρουαρίου 2025 ξεκίνησε η ύφεση της σεισμικής κρίσης και η δραστηική μείωση μετά τις 14 Φεβρουαρίου 2025.

Προκλήθηκε ηφαιστειακός θόρυβος, όπως είχε αναφερθεί;

Όχι. Υστερα από αναλύσεις δεν διαπιστώθηκε κάτι τέτοιο.

Φτάσαμε κοντά στο να γεννηθεί ένα νέο ηφαίστειο στη Σαντορίνη;

Όχι, δεν εντοπίστηκε μέσω της σεισμικότητας μαγματική δραστηριότητα κοντά στην επιφάνεια της Γης.

Υπήρξε κίνδυνος άμεσης έκρηξης του ηφαιστείου;

Όχι.

Συνδεόταν όλη αυτή η δραστηριότητα με το ρήγμα της Αμοργού που έδωσε τον καταστροφικό σεισμό του 1956;

Όχι.

Από τι προήλθε η εδαφική παραμόρφωση στο νησί;

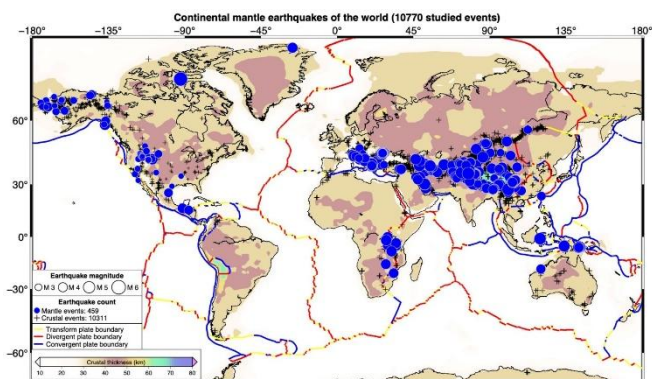
Είναι ένα θέμα προς συζήτηση. Υπάρχουν δύο εκδοχές. Σύμφωνα με επιστημονική δημοσίευση στην οποία συμμετέχει και ο διευθυντής Ερευνών του Γεωδυναμικού Ινστιτούτου, δρ Α-

θανάσιος Γκανάς, οφειλόταν σε σεισμική κίνηση, ενώ σύμφωνα με ετέρα επιστημονική δημοσίευση στην οποία συμμετέχει και η καθηγήτρια του ΕΚΠΑ, δρ Παρασκευή Νομικού, οφειλόταν σε διείσδυση φλέβας μάγματος. Προς διερεύνηση παραμένει και το είδος των ρευστών που ενεπλάκησαν στο φαινόμενο.

(Κατερίνα Ροββά / ΤΑ ΝΕΑ, 17/02/2026,
<https://www.tanea.gr/print/2026/02/17/greece/mythoi-kai-alitheies-lfgia-ti-seismiki-krisi/>)

'Impossible' mantle earthquakes actually occur all over the world, study finds

Researchers were once unsure whether mantle earthquakes existed. Now they have a global map of this mysterious phenomenon.



Continental mantle earthquakes happen around the globe. (Image credit: Axel Wang)

Earthquakes that jiggle Earth's middle layer may be more widespread than scientists thought.

A new map of these mysterious deep earthquakes shows that they occur all around the world and that they may have a variety of causes. That's interesting, said study senior author Simon Klemperer, a geophysicist at Stanford University, because mantle earthquakes were once thought to be impossible, or at least rare. These quakes originate below a border known as the Mohorovičić discontinuity, or "Moho" — the line between the brittle crust and the hotter, gooier mantle.

"We believe this firmly demonstrates that there are earthquakes below the Moho in very many regions of the world," Klemperer told Live Science. "It's not just special places. It's possibly ubiquitous."

Most earthquakes start in the crust, which is like a layer of toasted sugar over the softer, more deformable cream filling that is the mantle. This brittle crust can't deform, so it cracks under stress, causing the ground to shift and shake. For a long time, geoscientists thought this couldn't happen in the mantle, which has a taffy-like texture and tends to ooze instead of snap. But over the years, seismologists studying earthquakes have turned up evidence of quakes with deep origin points more than 22 miles (35 kilometers) down, which would put them below the Moho.

But pinpointing these quakes is difficult, especially when they are not large. In general, these earthquakes are so deep that they can't be felt at the surface, regardless of their size. The Moho's depth also varies from place to place, so it's possible that some very deep quakes are still in the crust.

Traditional methods of pinpointing mantle quakes required a specific understanding of how thick the crust might be in that particular location. But Klemperer and his co-author, Stanford doctoral student Shiqi Wang, developed a method that uses specific types of earthquake shear waves that tend to get trapped in either the crust or the mantle. The pattern of these waves in each individual earthquake can determine whether it's likely to have started above or below the Moho.

First, they tested the method in [Tibet in 2021](#). Now, in a new paper published Feb. 5 in the journal [Science](#), they have taken the research global. The researchers excluded subduction zones, which often have deep earthquakes because rocks from the crust get pushed into the mantle in these regions. Instead, the team focused on the more elusive phenomenon of mantle earthquakes under the continents.

They found mantle quakes all over the place. A dense band of them stretches from the Alps to the Himalayas, probably related to the mountain-building continental collisions in these regions. Another cluster occurs in [East Africa, where the continental crust is rifting apart](#). There are also mantle earthquakes under the western United States and in Baffin Bay, Canada, the researchers found.

Some of the cluster locations were surprising. "There were some regions where nobody had found these before, like in the Bering Sea," [Vera Schulte-Pelkum](#), a geologist at the University of Colorado Boulder who was not involved in the study, told Live Science. "I'd love to get an interactive version of these and zoom around."

The global overview should allow other scientists to do more specific studies on individual mantle quakes, Klemperer said, and perhaps better pinpoint their depths and the mechanisms driving the earthquakes.

"It's tremendously exciting that we have this tool that can now be applied on a very routine basis," he said.

Article Sources

Wang, S., & Klemperer, S. L. (2026). Continental mantle earthquakes of the world. *Science*, 391(6785), 611–615. <https://doi.org/10.1126/science.adz4367>

(Stephanie Pappas / LIVESCIENCE, 15 Feb. 2026, <https://www.livescience.com/planet-earth/earthquakes/impossible-mantle-earthquakes-actually-occur-all-over-the-world-study-finds>)

Continental mantle earthquakes of the world

Shiqi Wang and Simon L. Klemperer

Editor's summary

Deep earthquakes tend to cluster near subduction zones and can be explained by plate motions; however, this is not so for continental mantle earthquakes, which are hard to explain and even harder to detect. Wang and Klemperer developed a method that uses regional seismic waves and their relative amplitudes in the context of nearby recorded crustal earthquakes. Applied globally, this approach has detected more than 400 continental mantle earthquakes since 1990. These mantle earthquakes generally occur in areas that also have crustal earthquakes, but regional distributions suggest that mantle earthquakes occur under a wider range of tectonic and thermal conditions than previously thought. —Angela Hessler

Abstract

Continental mantle earthquakes (CMEs) and their implications for the rheological structure of continents have fascinated geophysicists for more than half a century. Existence of these earthquakes is no longer debated, but their identification remains sparse across the globe. Comparing the S_n and L_g seismic wave amplitude ratio (S_n/L_g) of an earthquake with that of nearby earthquakes distinguishes CMEs and, unlike previous methods, can be applied globally. We present a global distribution of CMEs that extends well beyond previous individual detections and areas of speculation. CME occurrence is widespread globally yet patterned regionally, reflecting local lithospheric structure and tectonic history. Our results highlight the value of CMEs for understanding continents and global tectonics.

Science, 5 Feb 2026, Vol 391, Issue 6785, pp. 611-615, [DOI: 10.1126/science.adz4367](https://doi.org/10.1126/science.adz4367)

Fault Mechanisms and Focal Mechanism Solutions

Fault mechanisms describe the movement and deformation that occur along fractures in the Earth's crust during an earthquake. These movements are recorded and analyzed through focal mechanisms, which are graphical representations showing the orientation of fault planes and slip directions. A focal mechanism solution, often called a beachball diagram, is derived from seismic wave data and helps geologists understand whether the faulting is due to compression, extension, shear, or a combination.

Types of Fault Mechanisms

1. Strike-Slip/Shear Faulting

Characterized by horizontal motion along the fault plane.

Blocks slide past each other laterally with little vertical movement.

Common along transform plate boundaries (e.g., San Andreas Fault).

2. Normal/Extension Faulting

Occurs when the crust is stretched, causing one block to move downward relative to the other.

Typical of divergent plate boundaries such as mid-ocean ridges and rift valleys.

3. Reverse/Thrust/Compression Faulting

Formed under compressional forces, where one block is pushed upward over the other.

Common at convergent plate boundaries such as subduction zones and mountain belts.

4. Transtension (Extension + Shear)

Combination of strike-slip and extensional movement.

Occurs in oblique divergent settings, where crust is both pulled apart and sheared laterally.

5. Transpression (Compression + Shear)

Combination of strike-slip and compressional movement.

Found in oblique convergent settings, where crust is both pushed together and sheared.

Focal Sphere and 2d Projection

The focal sphere represents the 3D distribution of seismic wave radiation from an earthquake.

Its 2D projection (beachball diagram) provides a simplified way to interpret the fault type and stress orientation.

Conclusion

Focal mechanism solutions are essential tools in seismology and structural geology. They not only help identify faulting styles but also improve our understanding of plate tectonic processes and seismic hazards.

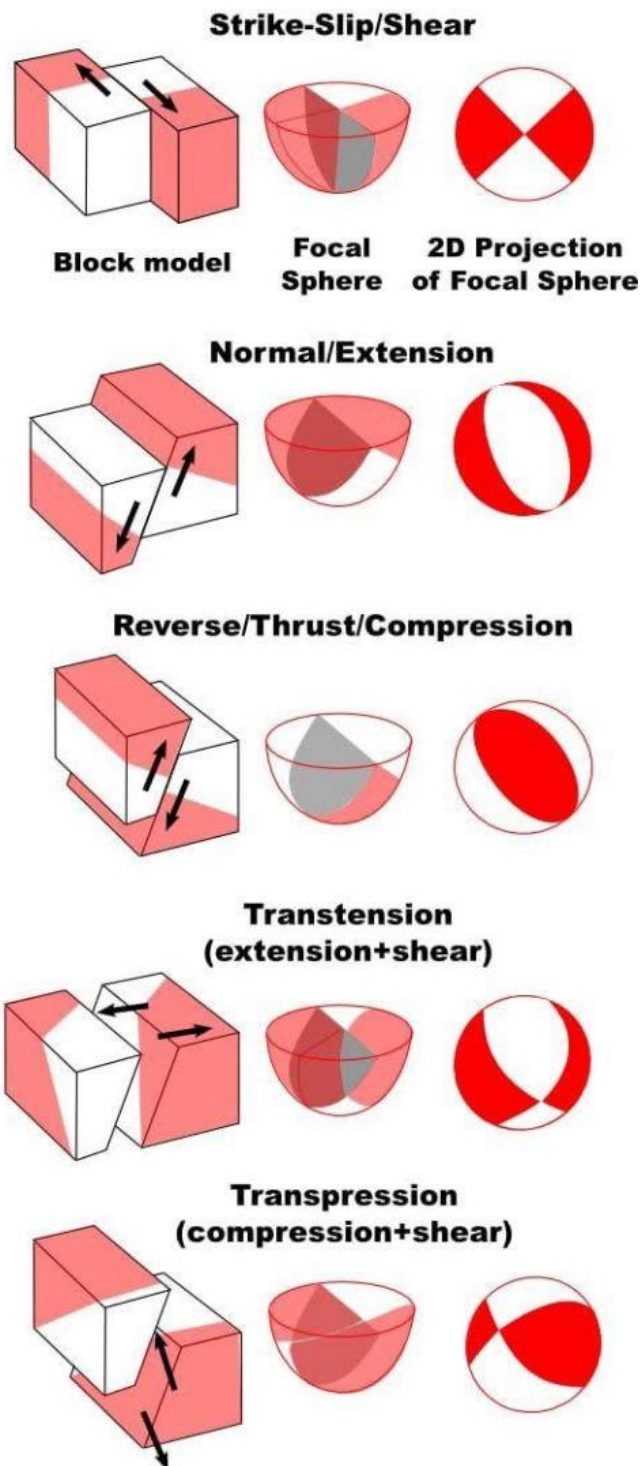


Image Source: Adapted from structural geology and seismology educational materials.

<https://www.linkedin.com/in/nwafor-isaac-63223b239/recent-activity/all/>

Growth Faults and Sediment Deposition over Evaporite Layers

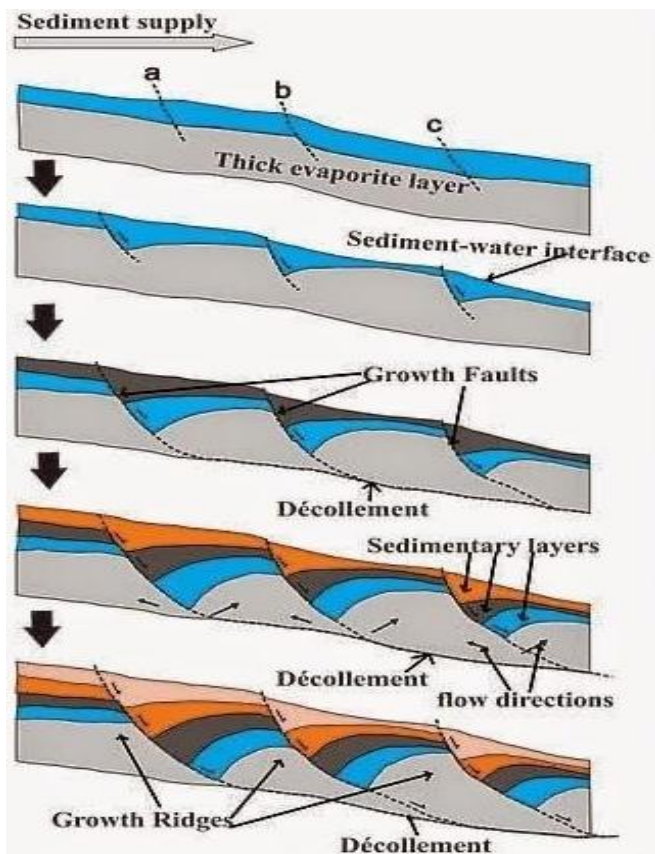


Image Source: Adapted from research illustrations on sediment deformation above evaporite layers.

Introduction

Growth faults are syndepositional normal faults that form during sedimentation and are characterized by increasing displacement with depth. They commonly occur in areas where thick, ductile evaporite or shale layers act as a detachment (décollement) surface, allowing overlying sediments to deform as they accumulate. These structures play an important role in sediment redistribution, basin subsidence, and hydrocarbon migration pathways.

Description of the Process:

1. Initial Stage: Sediment supply begins over a thick evaporite layer, with the sediment-water interface resting above the salt.
2. Early Fault Initiation: Differential loading of sediments causes movement within the ductile evaporite, leading to the formation of incipient growth faults.
3. Fault Development: Continued sedimentation causes the faults to propagate downward to the décollement, creating tilted fault blocks and associated subsidence areas.
4. Sedimentary Layering: New sediments fill the downthrown blocks, and older layers are progressively rotated. Fault displacement increases with depth.
5. Growth Ridge Formation: Flow within the evaporite creates uplifted zones (growth ridges) and subsided areas, influencing later sediment distribution and fault geometry.

Definition of Key Terms:

Growth Faults: Faults that form contemporaneously with sediment deposition, showing thicker sediment accumulation on the downthrown side.

Décollement: A detachment surface, often within a ductile layer such as salt, allowing independent movement of overlying strata.

Growth Ridges: Elevated zones formed by flow and accumulation of ductile evaporite material beneath the sediments.

Geological Significance:

Growth faults indicate active tectono-sedimentary processes, influence subsurface fluid migration, and often form structural traps for hydrocarbons. Their association with evaporite layers makes them common in passive margin basins and deltaic environments.

<https://www.linkedin.com/in/nwafor-isaac-63223b239/recent-activity/all/>

Growth Faults and Associated Structures

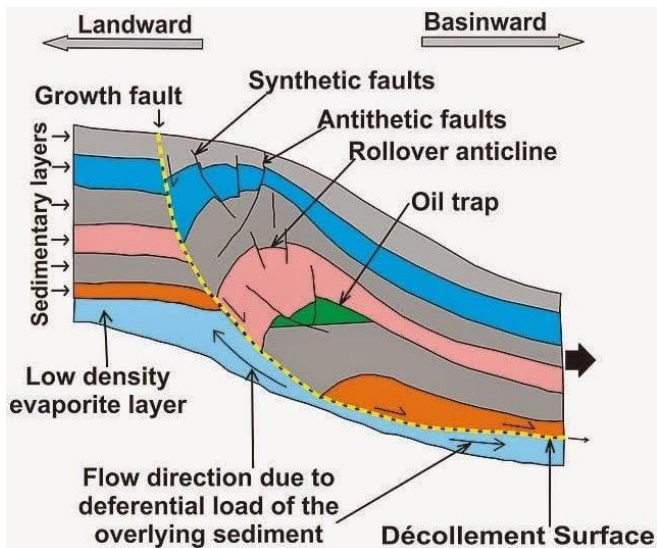


Image source: ResearchGate

Introduction/Definition

Growth faults are syndepositional faults that develop contemporaneously with sediment deposition. They typically form in sedimentary basins where thick, rapidly deposited sediments accumulate over a mechanically weak layer, such as salt or shale. The differential loading of sediments causes movement along a detachment surface (décollement), leading to faulting, folding, and associated structural traps.

The image below illustrates the formation and structural features associated with a growth fault system. Sedimentary layers are displaced due to the movement along a low-density evaporite layer. The main features include:

- Growth Fault: A major fault that develops during sediment deposition, causing thicker sediment sequences on the downthrown side.
- Synthetic Faults: Secondary faults dipping in the same direction as the growth fault.
- Antithetic Faults: Secondary faults dipping in the opposite direction to the main fault.
- Rollover Anticline: A fold structure created in the hanging wall of the growth fault, often acting as a hydrocarbon trap.
- Oil Trap: A structural feature where hydrocarbons accumulate due to impermeable barriers formed by faults and folds.
- Low-Density Evaporite Layer: A weak, ductile layer (e.g., salt) that flows under differential sediment load, facilitating fault movement.
- Décollement Surface: The detachment zone along which displacement occurs.
- Flow Direction: Movement within the evaporite layer caused by the uneven load of overlying sediments.

Geological Significance:

Growth faults are important in petroleum geology because they often create traps for oil and gas accumulation. Their association with rollover anticlines and sealing evaporite layers makes them prime targets in hydrocarbon exploration.

<https://www.linkedin.com/in/nwafor-isaac-63223b239/recent-activity/all/>

Missing megaflood: How did the Mediterranean transform from a salt-filled bowl to a deep sea if it wasn't a cataclysmic deluge?

Dana Mackenzie

Researchers have long believed that a sudden, massive deluge filled a dry, salt-filled Mediterranean 5 million years ago. Turns out that probably didn't happen, but there was still drama aplenty.



(Image credit: SALTGIANT)

On October 6, 1970, the deep-sea drilling vessel *Glomar Challenger* returned to port in Lisbon, Portugal, bearing a cargo that would revise history. During its 54-day voyage, the *Challenger* had punched 28 holes into the bottom of the Mediterranean Sea. The recovered cores pointed toward a startling conclusion: About 6 million years ago, the sea had turned into a desert: a vast, barren, salt-filled bowl more than two kilometers [1.2 miles] deep. Half a million years after that, the Atlantic Ocean had burst through what is now the Strait of Gibraltar and unleashed the largest flood in history.

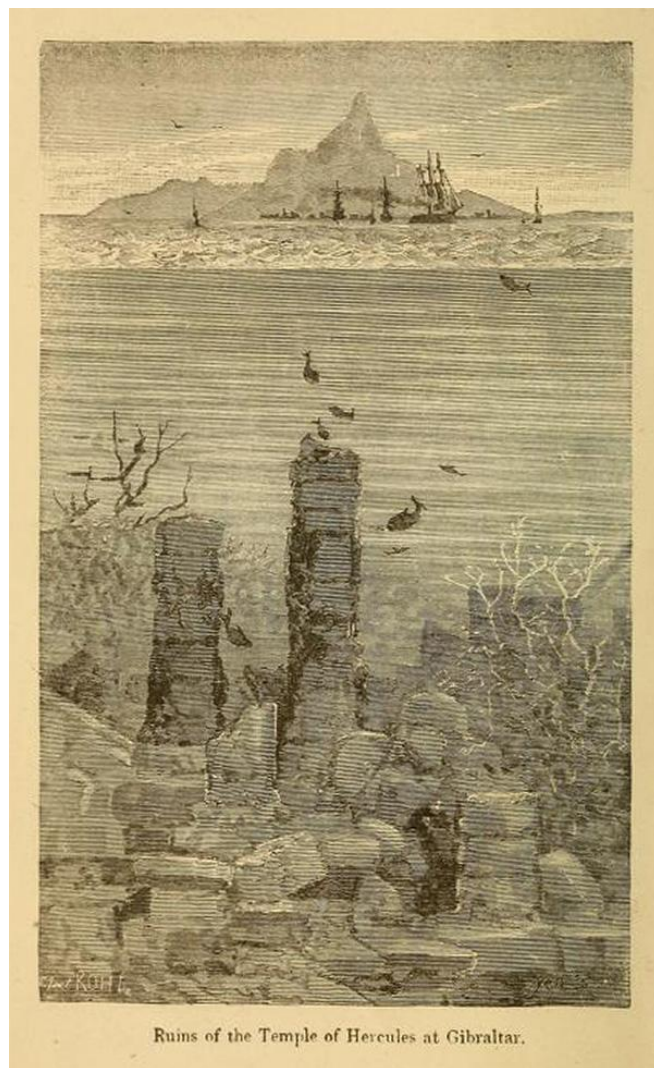
Kenneth Hsü, an oceanographer who was one of the two lead scientists on the *Challenger* expedition, imagined the scene vividly in the December 1972 issue of *Scientific American*:

"Cascading at a rate of 10,000 cubic miles per year, the Gibraltar Falls would have been 100 times bigger than Victoria Falls and 1,000 times more so than Niagara.... What a spectacle it must have been for the African ape-men, if any were lured by the thunderous roar."

The catastrophe story was a hit: David Attenborough filmed a documentary about it, and Gibraltar even issued a 5-pence stamp portraying the "3,000-metre waterfall." The two hypotheses — first, that the Mediterranean Sea became land-locked during a half-million-year period known as the Messinian salinity crisis, and second, that it was restored by a cataclysmic deluge through the Strait of Gibraltar, dubbed the Zanclean flood — have been conventional wisdom among geologists for more than 50 years.

However, fresh doubts have arisen recently about every part of this story, from the mega-desert to the mega-Niagara. Many geologists have argued for a much briefer desiccation followed by a far more gradual refilling of the Mediterranean. Some think that the Mediterranean never completely disconnected from the Atlantic at all. "The idea of a megaflood, and the data that supports it, are mostly flawed," says Guillermo Booth Rea of the University of Granada in Spain.

The most startling recent twist is that the floodway, if there was one, may not have been anywhere near the present-day Strait of Gibraltar, which separates southern Spain from Morocco. For 50 years, new research suggests, we have been looking for signs of a megaflood in the wrong place.



Ruins of the Temple of Hercules at Gibraltar.

Cataclysmic floods feature in many stories of mythology and creation. In one such legend, classical hero Hercules cleaves apart two mountains (the "pillars of Hercules"), creating the Strait of Gibraltar and flooding the Mediterranean basin. The above image shows an artist's conception of a now submerged temple to Hercules at Gibraltar. (Image credit: L. SONREL / THE BOTTOM OF THE SEA 1872)

A geological conundrum

In the present-day Mediterranean, about three times more water is lost every year to evaporation than is recaptured from rainfall and rivers. The Atlantic makes up for the difference, supplying a steady west-to-east current of seawater through the Strait of Gibraltar. As the sea's water evaporates, the remaining water becomes saltier and denser and sinks to the bottom. The dense water then flows back out of the strait, east to west, underneath the less dense inbound water. This outflow prevents salt from accumulating in the Mediterranean.

But what would happen if the strait were constricted, or shut off entirely? Given the hugely negative budget of fresh water, "sea level" in the Mediterranean Sea would drop rapidly, by as much as a kilometer in 2,000 years. Such a scenario would have seemed like science fiction until the *Glomar Challenger*'s 1970 expedition.

At the first drill site, the *Challenger*'s drill bit jammed on a very hard layer 200 meters below the bottom of the sea. The next day, Hsü and his co-lead scientist, William Ryan of Lamont-Doherty Earth Observatory, found out why. "It brought up buckets full of gravel," Ryan says.

Seafloors don't often contain beds of gravel, and when they do, it is usually continental rocks washed down from the adjacent land. But this gravel had marine fossils and rock, mixed with crystals of gypsum. Geologists call gypsum an "evaporite," because in the present-day world it forms in evaporating shallow bodies of water — as in the Dead Sea, for example. The implication was startling. "When Ken held up the gypsum crystals, he turned to me and asked, 'Do you think the Mediterranean dried out?'" Ryan remembers.

The same story was repeated at every stop. Ryan and Hsü found other evaporites like halite (sodium chloride, aka table salt). Oxygen isotopes in seashells embedded in the gravel suggested that these unlucky animals had lived in a brine from which 90 percent of the original water had evaporated. Hsü and Ryan also gathered evidence that the colliding of the African and Eurasian tectonic plates had lifted up the land on both ends of the Mediterranean Sea, closing its former connection with the Indian Ocean and narrowing the connection with the Atlantic Ocean.

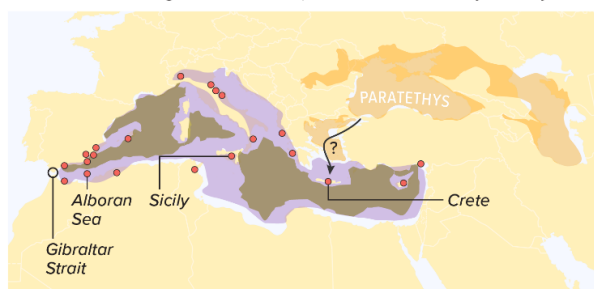
Fluctuating sea levels and gradual refilling of the Mediterranean

Mediterranean region present day:



Mediterranean Sea levels 5.3 mya – 5.5 mya:

● Low-stand ● High-stand ● Sampled sites ● Paratethys lake system



SOURCE: ADAPTED FROM W. KRUGSMAN ET AL. / NATURE REVIEWS EARTH & ENVIRONMENT 2024

KNOWABLE MAGAZINE

The layout of the Mediterranean during the third stage of the Messinian salinity crisis has been particularly controversial: Some believe that the Mediterranean was nearly dry; others believe it was nearly full. Recent research suggests the answer may be both. The Mediterranean basin may have refilled with freshwater from the ancient Paratethys lake system to the east, while sea levels also fluctuated due to climate changes. The high water (purple) and low water (brown) levels of this period (5.33 to 5.55 million years ago) are shown on the bottom map. (Image credit: Knowable Magazine)

The clinching piece of evidence came to light after the Challenger mission had ended. Other geologists discovered what appear to be buried ancient beds of several rivers that flow into the Mediterranean, particularly the Nile and the Rhône. It looked as if those rivers once emptied into the Mediterranean at least a kilometer *below* their present outlets — something that would be possible only if the sea level of the Mediterranean had been a kilometer [0.6 miles] below the global sea level at some point in the past.

In 1973, a meeting in Utrecht, Netherlands, established the desiccation model as the consensus theory. But a considerable amount of dissent has emerged in the last 20 years. "In the 1970s, the desiccation people won the debate," says Wout Krijgsman of Utrecht University, "but there are several aspects it cannot really explain."

Paradoxes galore

In part, the dissent reflects an improved understanding of what was occurring on Earth and in the area 6 million years ago. Since 1973, the story told by rocks, core samples and seismic soundings — and, increasingly, by computer simulations — has become more detailed and more dynamic, with changing shorelines, land bridges and volcanoes, and repeated episodes of climate change.

Also, there were fundamental problems with the desiccation hypothesis to begin with. Take the evaporites, for example: They do not have to form via evaporation, says sedimentologist and stratigrapher Vinicio Manzi of the University of Parma in Italy. They can also form by precipitation from a sufficiently concentrated brine. This can happen underwater, so there is no need to posit that the Mediterranean went bone dry.

And the buried riverbeds? Those, too, Manzi and his colleagues [can explain](#): The sinking of briny water can produce downhill currents ("dense shelf water cascading," in geology lingo) sufficiently strong to scour out a canyon.

The idea of a single evaporation event also faces a mathematical problem: The existing salt deposit is too big to be explained by a single evaporation event. It represents about 5 percent of the salt in the world's oceans (and may have originally been 7 to 10 percent). To collect that much salt, the Mediterranean would have had to empty and refill about 10 times.

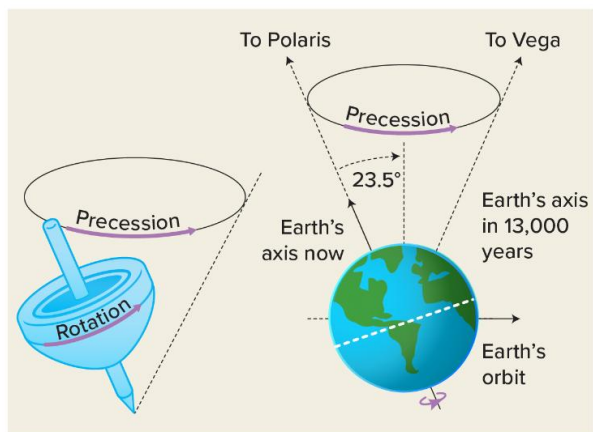
In fact, evidence from salt deposits in Sicily suggests something like that actually happened. There, gypsum beds alternate with shale beds that are rich in organic material and could have formed in periods when the gateway between the Atlantic and Mediterranean was open. There are 16 beds in all, with ages spaced about 23,000 years apart.

This periodicity is well known to geologists: It's the time it takes for Earth's axis (like a wobbly top) to trace one complete circle. And it correlates with changes in climate and ancient sea levels the world over. With the presumptive Gibraltar gateway being so shallow during this period, sea level fluctuations due to this "precessional cycle" could have repeatedly opened and closed the connection between the Mediterranean Sea and the Atlantic.

That period of gypsum formation is now called Stage 1 of the salinity crisis. Stage 2 was a relatively brief 50,000-year period when (in the majority opinion) the gateway slammed entirely shut, the sea level in the Mediterranean plummeted, and huge deposits of halite (sodium chloride) precipitated out from the seawater. However, Manzi's group strongly dissects, arguing that the Gibraltar gateway remained open, but shallowed to such an extent that the water flowed through it in one direction only — in but not out — resulting in a runaway buildup of salt.

Even for adherents of the majority view, Stage 2 is not as simple as it seems. Data from chlorine isotopes suggest that the drawdown was not uniform. At its lowest point, in the western Mediterranean, sea level was 800 meters below its present level, while east of present-day Sicily it was at least twice as deep as that. If so, the east and west portions must have been separated by a land bridge. Indeed, there is evidence of African animals crossing over to Europe during this time.

Precession of the Earth's Axis



SOURCE: ADAPTED FROM COSMOS AT YOUR DOORSTEP

KNOWABLE MAGAZINE

Like a wobbly spinning top, the Earth's axis of rotation also moves in a slow circle, completing a full cycle once roughly every 23,000 years. This precession of Earth's axis influences the climate, and did so during the Messinian salinity crisis, with gypsum deposits precipitating during dry periods and shale during wet periods. (Image credit: Knowable Magazine)

The last 200,000 years of the salinity crisis, called Stage 3, have been the most puzzling of all. The halite stopped precipitating and there is evidence for a variety of sea levels in the Mediterranean during this time. Widespread fossils of a shrimp-like animal called an ostracod suggest that the waters became much less salty, so that the Mediterranean was a sea-sized lake (and indeed, this stage is sometimes called the Lago-Mare stage). But if the gateway to the Atlantic was still closed, then where did the fresher water come from?

A 2025 paper by Daniel García-Castellanos of the Spanish National Research Council helps solve the puzzle. Using a computer to model erosion, he argues that the Mediterranean was gradually refilling during Stage 3. The ostracods provide a clue to the source. They originated from the area of the present-day Black and Caspian Seas, which back then were connected to each other, but not to the Mediterranean.

With the shores of the Mediterranean being so newly exposed and so steep, its edges would have rapidly eroded toward today's Black Sea, which at that time was a much larger freshwater lake called the Paratethys. The first connection between them could have been established at this time. If so, the Mediterranean began to receive waters from rivers like the Volga, the Don and the Danube, which had previously been unavailable. The ostracods got a new home, and the Mediterranean got a vast new supply of water, which according to the computer simulation raised its surface to within 300 meters of its current level.

According to Krijgsman, this interpretation conveniently reconciles the conflicting evidence. "In the fight between a desiccated and full Mediterranean," says Krijgsman, García-Castellanos' paper does the job "if you want to sit in the middle and give everyone credit for their observations."

Missing: One megaflood

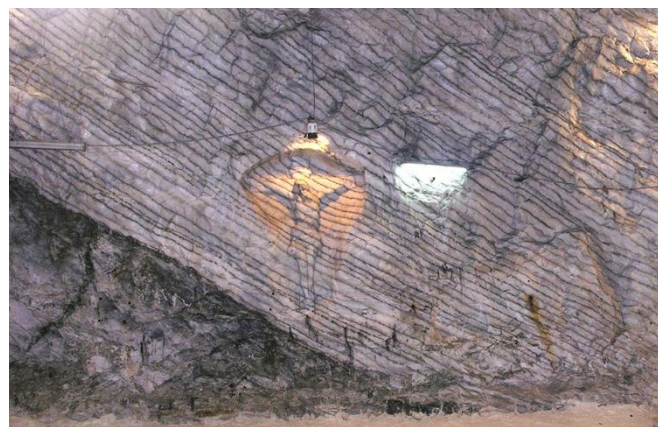
The literature on the Messinian salinity crisis is voluminous, and yet one thing is curiously absent. There is surprisingly little direct evidence of the megaflood that supposedly ended the crisis. Hsü's original *Scientific American* article devotes only half a page to it and adduces little in the way of evidence. Fifty years later, Ryan wrote a 100-page retrospective; only three pages are about the megaflood. Shouldn't this extraordinary flood have left very clear scars?

The current evidence is ambiguous at best. Geologists have found submerged flood-like deposits off Malta — but that's a long way from Gibraltar, the putative source of the flood. Also, if the Atlantic drained into a nearly empty Mediterranean basin, then sea levels around the world should have dropped by about nine meters — an anti-flood to pay for the Mediterranean flood. There is no sign that this happened, says García-Castellanos.

A recent deep-sea drilling expedition to the Strait of Gibraltar turned up more questions than answers. In December 2023, the JOIDES Resolution — heir to the *Glomar Challenger* — revisited the Alboran Sea immediately to the east of the Strait of Gibraltar. If the strait is the door to the Mediterranean, then the Alboran Sea is the vestibule. Any megaflood that passed through the Strait of Gibraltar would have passed also through the Alboran basin. But Rachel Flecker of the University of Bristol, England, co-leader of the expedition, says they found no traces of the flood in the cores they collected.

While still on board the ship, she wrote that the cores were "exquisitely laminated in a variety of colors. This incredibly fine lamination requires very quiet, low energy conditions." Exactly the opposite of a megaflood. Final results have not been published yet, but Flecker reports also that they found no salt layer and no evidence that the salinity crisis had ever touched the Alboran Sea.

"The connection between the Atlantic and Mediterranean before and during the Messinian salinity crisis wasn't through Gibraltar," she concludes.



The Realmonte salt mine in Sicily contains spectacular bedded salt formations deposited during Stage 2 of the Messinian salinity crisis. Remarkably, each bed of salt, demarcated by distinct lines in this photo, was deposited in a single year (unlike the gypsum deposits of Stage 1, which were deposited in 23,000-year cycles). The statue of Jesus was added some 5.5 million years later by miners who carved a cathedral out of the salt. (Image credit: VINICIO MANZI)

How can this be? "A feature that you must take into account, and nearly nobody does, is that the present physiography of the Mediterranean is very different from the Messinian one," says Booth Rea. "Large basins have opened since, like the Tyrrhenian; other regions have emerged, like Sicily." One possibility, he suggested, is that the gateway was somewhere to the east, through a volcanic arc of islands that once connected Africa to the Balearic Islands. Other possibilities include channels through Spain or Morocco, which are above sea level now but were underwater as recently as 7 million years ago.

Regardless of how it happened, this modern view of the story holds lessons: It emphasizes the power not of dramatic events but of small changes. "Salt giants" — that is, massive salt deposits like the one underneath the Mediterranean —

have formed at other times in Earth's history, when basins were trapped between two tectonic plates. Their effects on climate and biodiversity have likely been huge: In this event, 89 percent of exclusively Mediterranean marine species died out.

And a slight shallowing of the Strait of Gibraltar (or whatever the true gateway was) might be all that was needed to trigger these vast changes. "In some sense, this is more terrifying," says Manzi, because it shows that "you can reach extreme conditions without extreme events."

This article originally appeared in [Knowable Magazine](#), a non-profit publication dedicated to making scientific knowledge accessible to all.

The cataclysmic flood that wasn't

Researchers have long believed that a sudden, massive deluge filled a dry, salt-filled Mediterranean some 5 million years ago. Turns out that probably didn't happen, but there was still drama aplenty.

By [Dana Mackenzie](#) 02.09.2026, <https://knowablemagazine.org/content/article/physical-world/2026/case-against-zanclean-megaflood-filling-mediterranean>)

(LIVESCIENCE, Feb. 18, 2026, <https://www.livescience.com/planet-earth/weather/missing-megaflood-how-did-the-mediterranean-transform-from-a-salt-filled-bowl-to-a-deep-sea-if-it-wasnt-a-cataclysmic-deluge>)

Hidden slippery clay on seafloor may have worsened devastating 2011 tsunami in Japan

A thick layer of slippery clay on the ocean floor may have formed the weak spot that enabled a magnitude 9.1 quake to make such a devastating tsunami.



The 2011 earthquake — the largest ever recorded in Japan — triggered a 130-foot-high tsunami that caused huge devastation. The event killed more than 18,000 people. (Image credit: Satoshi Takahashi/LightRocket via Getty Images)

The 2011 Tohoku earthquake that triggered a devastating tsunami in eastern Japan was worsened by a thick layer of slippery clay, new research finds.

The clay layer, which was up to 98 feet (30 meters) thick on the ocean floor, created a weak spot that enabled the magnitude 9.1 quake's movement to travel all the way to the seafloor. That motion thrust the seafloor upward by 164 to 230 feet (50 to 70 m) over about 310 miles (500 kilometers). And the motion of the seafloor thrusting into the overlying ocean is what created the tsunami wave that inundated 217 square miles (561 square kilometers) of Japan.

"It's low-friction, so that clay is weak," said Ron Hackney, a geophysicist at the Australia National University and the director of the Australian and New Zealand International Scientific Drilling Consortium. "It can slip very easily."

The side-to-side breakage of the fault was about half of what researchers would have expected, Hackney told Live Science, which concentrated the upward motion into a smaller area, probably intensifying the resulting tsunami. The findings explain why the tsunami was larger and more concentrated than expected, he said, and these kinds of detailed studies can help provide better warnings for future quakes.

"We can be a bit more prepared in terms of informing people of what to expect and how to respond when an earthquake does happen," he said.

The 2011 quake happened along a subduction zone, where the Pacific Plate slides under Japan. In 2024, Hackney and other researchers aboard the research vessel *Chikyu* drilled directly into the fault that caused the quake. After drilling 23,000 feet (7,000 m) below the ocean surface and another 3,300 feet (1,000 m) below the seafloor, they pulled up cores of sediments from within the fault and from the Pacific Plate.

They found that the Pacific Plate is covered with a thick, goopy layer of clay that has been accumulating slowly for around 130 million years. This layer compresses as the Pacific Plate pushes under Japan, also squeezing the continental rocks above. The result is a mechanical weak point, almost like a perforation on a piece of notebook paper, where the rock is prone to breaking.

The researchers published their findings December 2025 in the journal [Science](#).

Similar clay layers may or may not exist at other subduction zones, Hackney said. There is some evidence that they might be present near Sumatra, Indonesia, the site of the magnitude 9.1 earthquake that caused a devastating tsunami on Dec. 26, 2004. But less is known about the materials coming into the fault zone at places like the Kamchatka Peninsula, where large quakes also occur, he said.

Hackney and his colleagues are working to find links between topography and rock density and ultimate earthquake movement. Earth scientists are getting increasingly good at predicting how large a quake will be and where the shaking will be felt once a quake happens, enabling early warning systems that can alert people to incoming shaking seconds to minutes in advance. Tsunami warnings have an even longer lead time, so perfecting the understanding of how the seafloor moves to better predict where a tsunami will go could save even more lives.

Article Sources

Kirkpatrick, J. D., Savage, H. M., Regalla, C., Shreedharan, S., Ross, C., Okuda, H., Nicholson, U., Ujiie, K., Hackney, R., Conin, M., Pei, P., Satolli, S., Zhang, J., Fulton, P., Ikari, M., Kodaira, S., Maeda, L., Okutsu, N., Toczko, S., & Eguchi, N. (2026). Extreme plate boundary localization promotes shallow earthquake slip at the Japan Trench. *Science*, 391(6784), 489–493. <https://doi.org/10.1126/science.adv0234>

(Stephanie Pappas / LIVESCIENCE, Feb. 17, 2026, <https://www.livescience.com/planet-earth/earthquakes/hidden-slippery-clay-on-seafloor-may-have-worsened-devastating-2011-tsunami-in-japan>)

Extreme plate boundary localization promotes shallow earthquake slip at the Japan Trench

J. D. Kirkpatrick, H. M. Savage, C. Regalla, S. Shreedharan, C. Ross, H. Okuda, U. Nicholson, K. Ujiie, R. Hackney, M. Conin, P. Pei, S. Satolli, J. Zhang, P. Fulton, M. Ikari, S. Kodaira, L. Maeda, N. Okutsu, S. Toczko, N. Eguchi, and Expedition 405 Scientists

Editor's summary

The 2011 moment magnitude 9.1 Tohoku-oki earthquake had the perfect storm of energetic, long slip on a shallow, subsea fault. The devastating tsunami that followed motivated efforts to understand the risk for shallow earthquakes in subduction zones. Kirkpatrick *et al.* report findings from the final cruise of the International Ocean Discovery Program, which drilled into the fault and undeformed seafloor. Sediment cores from both sites showed that the fault developed where a marine clay layer is juxtaposed against silica-rich mud or chert. The contrasting physical properties of sediment entering the subduction zone may facilitate shallow slip along the Japan Trench. —Angela Hessler

Abstract

The 2011 moment magnitude 9.1 Tohoku-oki earthquake is exceptional among great earthquakes for having peak slip of ~50 to 70 meters on the shallowest portion of the plate boundary megathrust. Drill cores and geophysical logs from International Ocean Discovery Program Expedition 405 demonstrate that the megathrust preferentially develops at the top or base of the pelagic clay in the sedimentary layers present on the incoming Pacific Plate, where pronounced contrasts in physical properties occur. This preference results in a narrow, weak fault located at a major mechanical contact between frontal prism mud and subducted sediments, which enhances the tendency for shallow seismic slip, suggesting

that the Japan Trench may be more susceptible to ruptures with large shallow slip than are margins without weak clays.

Science, 18 Dec 2025, Vol 391, Issue 6784, pp. 489-493,
[DOI: 10.1126/science.ady0234](https://doi.org/10.1126/science.ady0234)

Vanishing lakes in Tibet may have triggered earthquakes by awakening faults in Earth's crust

Shrinking lakes in Tibet likely woke up long-dormant tectonic faults, a new study finds. The findings strengthen the link between climate change and earthquakes



Nam Co Lake in Tibet. The region was once home to much bigger lakes that stretched for more than 125 miles. (Image credit: wx-bradwang / Getty Images)

Vanishing lakes in southern Tibet may have triggered earthquakes in the region by "awakening" long-dormant faults in Earth's crust, researchers say. The finding adds to evidence of an unexpectedly strong link between our planet's climate and the geological activity deep beneath our feet.

About 115,000 years ago, southern Tibet was home to enormous lakes, some more than 125 miles (200 kilometers) long. Today, those lakes are much smaller. They include Nam Co Lake (also called Namtso Lake or Lake Nam), which is just 45 miles (75 km) long.

A team of geologists led by [Chunrui Li](#), a researcher at the Chinese Academy of Geological Sciences in Beijing, suspected that water loss from the lakes might have had knock-on effects for the local geology. This is partly because large lakes weigh down Earth's crust. When they begin to dry up, that weight is lost and the crust slowly rises again, in much the same way that a heavily laden ship rises in the water as its cargo is removed.

A second key point is that southern Tibet is geologically active because of the ongoing collision between India and Eurasia, which began about 50 million years ago. Strain has built up in Earth's crust beneath southern Tibet, leaving ancient cracks — or faults — in the crust ready to rupture. The geologists reasoned that the slow rise of the crust caused by the shrinking lakes might have triggered such ruptures and generated earthquakes.

The researchers think that this has happened. They analyzed the local geology, mapping the ancient lake shorelines to work out how much water the lakes have lost. They then used computer models to predict how much the crust should have risen in response, revealing that this should have reactivated nearby faults.

The study was published Jan. 17 in the journal [Geophysical Research Letters](#).

Their analysis suggests that water loss from Nam Co Lake between 115,000 and 30,000 years ago led to a total of 50 feet (15 meters) of movement on a nearby fault. The lakes 60 miles (100 km) to the south of Nam Co Lake have lost even more water over the same time period. There, there may have been 230 feet (70 m) of movement on nearby faults.

These calculations suggest that the faults in the region have experienced between 0.008 and 0.06 inches (0.2 and 1.6 millimeters) of movement per year, on average. For comparison, the San Andreas Fault running through California records far more movement: about 0.8 inches (20 mm) each year, on average. But there, the movement is driven largely by processes occurring deep belowground. The new study is evidence that substantial movement on faults can also be affected by processes happening aboveground.

"Surface processes can exert a surprisingly strong influence on the solid Earth," [Matthew Fox](#), an associate professor of geology at University College London who was not involved in the study, told Live Science in an email. "Geologists are increasingly aware that to fully understand the evolution of a landscape or tectonic region, we need to consider this coupling between surface and deep Earth processes."

This doesn't mean earthquakes will occur whenever and wherever lakes are drying up, said [Sean Gallen](#), an associate professor of geology at Colorado State University who was not involved in the research. Such earthquakes will occur only where the lakes sit above crust that has accumulated strain because of tectonic activity. "Tectonics is always the driver," he told Live Science. "Changes in water load just alter how the built-up tectonic strain is released over time."

Strain can also be released by other surface processes, [Philippe Steer](#), an assistant professor of geosciences at the University of Rennes in France, told Live Science. Severe storms may trigger sudden and rapid erosion, removing heavy rock from some parts of the crust and allowing it to rise. Quarries where large amounts of rock are removed from the ground have a similar effect, said Steer, who was not involved in the study.

But perhaps the most significant "unloading" events in the recent geological past relate to the last glacial maximum. At that time, about 20,000 years ago, large chunks of North America and Eurasia were weighed down by enormous ice sheets, which were several miles thick in places. Those ice sheets had largely vanished by about 10,000 years ago. But because they were so heavy, the crust beneath where they once lay is still rebounding today.

Some researchers think this may help to explain a long-standing geological mystery. Almost all powerful earthquakes occur along major faults, like the San Andreas, that are found at the boundaries between Earth's tectonic plates. But occasionally, powerful earthquakes can occur in the middle of a tectonic plate, thousands of miles from one of these boundaries. For instance, in 1811 and 1812, there were three earthquakes of magnitude 7 or 8 along the Mississippi River valley in the central United States.

One idea is that strain slowly accumulated on ancient faults in the Mississippi River valley because of geological activity thousands of miles away, along the edges of the North American tectonic plate. Then, when the ice sheets melted and Earth's crust began to rise, that strain was released in the form of powerful earthquakes.

"While climate change does not 'cause' tectonics, it can modulate the stress conditions in the crust," Fox said. "That's something we need to factor into future hazard assessments."

Article Sources

Li, C., Li, H., Chevalier, M.-L., Pan, J., & Liu, F. (2026). Lake unloading drives fault slip and rift asymmetry in southern Tibet. *Geophysical Research Letters*, 53, <https://doi.org/10.1029/2025GL120955>

(Colin Barras / LIVESCIENCE, Feb. 17, 2026, <https://www.livescience.com/planet-earth/earth-quakes/vanishing-lakes-in-tibet-may-have-triggered-earth-quakes-by-awakening-faults-in-earths-crust>)

Lake Unloading Drives Fault Slip and Rift Asymmetry in Southern Tibet

Chunrui Li, Haibing Li, Marie-Luce Chevalier, Jiawei Pan, Fucai Liu

Abstract

The extent to which surface processes drive continental deformation remains a pivotal question in geodynamics. Here, we demonstrate that Late Quaternary lake-water unloading is a primary driver of fault slip and rift asymmetry in southern Tibet. Since the last interglacial (~116 ka), significant water-level drops of large lakes have induced crustal rebound and Coulomb stress changes. At Nam Co Lake, a ~130 m drop produced ~0.1 MPa of stress change, preferentially reactivating the adjacent fault and contributing ~15 m of vertical displacement ~23% of the total near Damxung. Likewise, the southern lakes (Yamzho Yumco and Puma Yumco) caused ~70 m of vertical displacement on the adjacent fault. We establish that climatically-controlled lake unloading can directly shape continental rifting by selectively enhancing fault slip on the lake-bounding side of the rift, thereby amplifying its structural asymmetry. This highlights a significant, quantifiable role of surface processes in actively shaping tectonic deformation.

Plain Language Summary

On the Tibetan Plateau, the drying of giant lakes is causing the Earth's crust to slowly rise—a process known as rebound—as the weight of water is removed. This uplift, in turn, pushes on nearby faults, making them more likely to slip. In this study, we show that the dramatic drop in lake levels since the last interglacial (about 116,000 years ago) has not only reshaped the landscape but also helped to activate dormant faults. For example, at Nam Co Lake, crustal rebound due to water loss accounts for nearly one-fifth of the total fault movement observed nearby. Similarly, at Yamzho Yumco and Puma Yumco Lakes, rebound has driven ~70 m of vertical fault displacement. Our work demonstrates that climate-driven lake drying not only reshapes the landscape but can also “awaken” dormant faults and influence the shape of massive rifts. This reveals a surprising link: changes in surface water can ultimately drive tectonic activity deep within the Earth.

Key Points

- Lake regression causes crustal rebound that enhances fault slip in southern Tibet
- Nam Co Lake unloading produced rebound up to 23% of total fault displacement near Damxung since ~116 ka
- Lake-induced rebound contributes to fault reactivation and promotes rift asymmetry in the Yadong–Gulu Rift

1 Introduction

Surface-load changes driven by climate variability and surface processes can modulate crustal stress and influence fault activity. Processes such as glacier retreat, erosion, and lake-level fluctuations are known to induce isostatic rebound and perturb regional stress fields, thereby promoting or inhibiting fault slip and seismic activity (Hampel et al., [2007](#); Hetzel & Hampel, [2005](#); Jeandet Ribes et al., [2020](#); Karow & Ham-

pel, [2010](#); Maniatis et al., [2009](#)). Although fault behavior over geological timescales is generally governed by tectonic forces (Davis et al., [1983](#)), over shorter timescales, particularly during the Late Quaternary, surface-load changes may play a significant role in modulating deformation patterns (Calais et al., [2010](#); Hurtado & Gallen, [2024](#); Steer et al., [2014](#)).

Previous studies documented the influence of surface unloading on fault systems in a wide range of tectonic settings, including normal faults (Foster et al., [2010](#); Hurtado & Gallen, [2024](#); Wernicke & Axen, [1988](#)), thrust faults (Steer et al., [2014](#); Turpeinen et al., [2008](#)), and strike-slip faults (Amos et al., [2014](#); Stein, [1999](#)). However, uncertainties remain regarding how surface-load changes interact with pre-existing fault geometries and whether such processes can systematically amplify structural asymmetry in extensional systems. In particular, few studies have quantitatively linked spatially heterogeneous surface loads to asymmetric fault slip in large continental rifts.

Here, we investigate whether Late Quaternary lake-water unloading influenced fault activity and rift architecture in southern Tibet. By integrating paleo-shorelines reconstruction, elastic flexural-isostatic modeling, and Coulomb failure stress (CFS) calculations, we test the hypothesis that climate-driven lake-level decline enhances slip on faults proximal to surface loads, thereby promoting along-strike and across-rift structural asymmetry. We focus on the Yadong–Gulu Rift (YGR), where large lakes are asymmetrically distributed relative to active rift-bounding faults, providing a natural laboratory for evaluating the tectonic effects of surface unloading.

...

Geophysical Research Letters, 17 January 2026, <https://doi.org/10.1029/2025GL120955> Digital Object Identifier (DOI)

Open Access

ΝΕΑ ΑΠΟ ΤΙΣ ΕΛΛΗΝΙΚΕΣ ΚΑΙ ΔΙΕΘΝΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΝΩΣΕΙΣ



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

ISSMGE News

www.issmge.org/news

2nd IS-GI 2027, Lyon - Save the date

Fanny Maucotel / [TC211](https://www.tc211.com) / 02-02-2026

International Symposium on Ground Improvement (IS-GI)
12-14 April 2027 Lyon, France

TC211 Ground Improvement is pleased to announce the dates of the second edition of the *International Symposium on Ground Improvement*. The event will be **coorganized with the French Society for Soil Mechanics and Geotechnical Engineering (CFMS)**.

Following the successful inaugural edition held in **Brussels in 2012**, organized under the auspices of **TC211**, the **Belgian Society for Soil Mechanics and Geotechnical Engineering (BGGG-GBMS)**, and **CFMS**, the 2027 symposium will once again bring together the international community to exchange knowledge and recent advances across all areas of **ground improvement**.

Event Dates and Venue

- **12-13 April 2027**
Centre de Congrès de la Cité Internationale, Lyon, France
- **14 April 2027**
Workshop Day at INSA Lyon

More information will be shared in the coming months.

Symposium website: <https://www.menard-group.com/isqi-lyon2027/>

We look forward to welcoming participants from around the world to **Lyon in April 2027**.



2nd IS-GI 2027, Lyon - Call for Abstracts

Fanny Maucotel / [TC211](https://www.tc211.com) / 02-02-2026

Call for Abstracts ISGI Lyon 2027

12-14 April 2027 Lyon, France

TC211 Ground Improvement is pleased to announce that the **Call for Abstracts is now open** for the second edition of the *International Symposium on Ground Improvement*, to be held on **12-14 April 2027** in **Lyon, France**.

We invite you to submit your abstract using the following link: [Abstract submission](#)

Abstract submission deadline: 15 May 2026

More Information

More details can be found on the symposium website: <https://www.menard-group.com/isqi-lyon2027/>

We look forward to receiving your contributions and discovering your work.

GeoJovem Brasil: Celebrating 75 Years of ABMS and Strengthening Young Geotechnical Engagement in 2025

Max Barbosa / Young Members / 05-02-2026

GeoJovem Brasil, the Young Members Group of the Brazilian Association for Soil Mechanics and Geotechnical Engineering (ABMS), reflect on a productive year in 2025 marked by technical exchange, academic engagement, and strong participation in national conferences.

In 2025, ABMS celebrated its **75th anniversary**, a milestone actively supported by GeoJovem Brasil through a series of initiatives aimed at connecting young professionals, academia, and senior experts in geotechnics.

Among the years highlights were **technical live sessions** with experienced professionals from different geotechnical fields. Special mention goes to the lecture by Prof. Vitor Faro (UFPR and Solution ID), *Transforming Geodata into Information: Selected Case Studies*, made available on the ABMS YouTube channel and widely attended by students and early-career engineers.

Another key initiative was the **GeoJovem Talk Show**, held during the **IX COBRAE / GEOSUL Conference** in Garibaldi, Brazil. **COBRAE (Brazilian Conference on Slopes)** focuses on slope stability, landslides, and geotechnical risk in natural and engineered slopes, while **GEOSUL** is a regional conference dedicated to geotechnical engineering in southern Brazil. During the event, GeoJovem representatives interviewed conference participants, promoting exchange of experiences and discussions on challenges and expectations within the young geotechnical community.

The year also featured the **Passa ou Recalca Geotechnical Challenge**, organized during the **7th GEONE Conference** in João Pessoa. **GEONE (Northeast Geotechnical Engineering Conference)** addresses regional geotechnical challenges and strongly encourages student and young professional participation. The competition brought together more than 15 young engineers in an interactive quiz format, strengthening links between the association and the academic community. The winners received ABMS memberships, as well as support and registration for **COBRAMSEG 2026**.

COBRAMSEG (Brazilian Conference on Soil Mechanics and Geotechnical Engineering) is the main national geotechnical conference in Brazil and the official ABMS event, held every two years, and will take place **this year in Brasilia**. It covers the full spectrum of geotechnical engineering topics and serves as the country's primary platform for technical exchange and Young Member activities.

Looking ahead to 2026, GeoJovem Brasil aims to continue promoting technical dissemination, integration, and opportunities for young professionals, maintaining a strong commitment to the geotechnical community and society at large.

Get Involved!

This update is part of the broader **YMPG News campaign**, showcasing initiatives from Young Members around the world.

Explore recent highlights:

- **Joint Young Members Austria: A Year of International Connection, Innovation, and Preparations for 2026**
<https://www.issmge.org/news/joint-young-members-austria-a-year-of-international-connection-innovation-and-preparations-for-2026>
- **Geotechnical Challenge 2025: Young Chilean Engineers Set Attendance Record**
<https://www.issmge.org/news/geotechnical-challenge-2025-for-young-chilean-geotechnical-engineers-sets-attendance-record>
- **BGA Early Career Group: 2025 Highlights**
<https://www.issmge.org/news/bga-early-career-group-2025-highlights>

We would love to hear from your Young Members Group too! To contribute an update or a short video from your country, please write to: ympg.issmge@gmail.com

Lets keep sharing and learning together across borders.

10th African Young Geotechnical Engineers Conference (AYGEC 2026) - 26–29 April 2026 | University of Lagos, Nigeria

Max Barbosa / Young Members / 11-02-2026

The **10th African Young Geotechnical Engineers Conference (AYGEC 2026)** will be held from **26 to 29 April 2026** at the University of Lagos, Nigeria.

Under the theme **Innovations and Best Practices in Geotechnical Engineering for African Development**, AYGEC 2026 will unite young geotechnical engineers from across Africa and around the world to exchange knowledge, share research, and build professional connections.

With abstract submissions now closed and the technical programme shaping up, the organising committee has released a short invitation video highlighting the spirit and goals of AYGEC 2026.

AYGEC 2026 Official Invitation Video

This conference is for young engineers by young engineers a platform to learn, connect, and lead the future of geotechnical engineering in Africa.

Watch the video on Instagram:

<https://www.instagram.com/reel/DL1tHU-otseU/?iqsh=MWq2N2lpcnhvaDdibw==>

Conference Highlights

- Keynote lectures and technical sessions
- Panel discussions on current geotechnical practice and emerging trends
- Technical tour to Eko Atlantic
- Exhibitions and networking events
- Young engineers' presentation competition (awards for top four presenters)

Keynote Speakers

- Dr. Marc Ballouz
- Dr. Chris Menkiti
- Prof. Marawan Shahien
- Prof. Mona Badr Anwar

Registration and Financial Support

Registration is open:

- **Registration Fee:** USD 200
- ISSMGE Member Societies are encouraged to sponsor at least two young participants.
- Young professionals seeking support may apply for the **ISSMGE Foundation Award** (January 2026 cycle).

More information: <https://nige.org.ng>

Organizer

Nigerian Institution of Geotechnical Engineers (NIGE)
conference@nige.org.ng

AYGEC 2026 – Strengthening the Global Young Geotechnical Network 26–29 April 2026 | University of Lagos, Nigeria

Max Barbosa / Young Members / 18-02-2026

As preparations advance for the **10th African Young Geotechnical Engineers Conference (AYGEC 2026)**, the event continues to gain strong digital visibility and international engagement.

To be held from **26 to 29 April 2026** at the University of Lagos, Nigeria, AYGEC 2026 will bring together young professionals under the theme:

Innovations and Best Practices in Geotechnical Engineering for African Development.

Beyond a regional conference, AYGEC represents a key pillar within the global ISSMGE Young Members ecosystem alongside initiatives such as iYGEC and other continental young engineers events strengthening leadership, technical excellence, and cross-border collaboration.

AYGEC 2026 Digital Momentum

The organising committee has recently released a new digital invitation reinforcing the countdown to Lagos and encouraging participation from across Africa and internationally.

AYGEC 2026 is a platform for connection, innovation, and leadership empowering young engineers to contribute actively to Africa's development.

Watch the latest update here:

<https://www.instagram.com/reel/DNbPi8FMxIQ/?igsh=MTA4aDhhbmg2b2h2>

AYGEC Within the ISSMGE Young Members Framework

Continental young engineers conferences such as AYGEC play a fundamental role in:

- Developing technical capacity among early-career professionals
- Encouraging young leadership within Member Societies
- Promoting diversity and inclusion, including the growing role of young African women in geotechnical engineering
- Creating bridges between academia, industry, and infrastructure development

The growing digital engagement around AYGEC 2026 reflects the increasing strength and organisation of the African young geotechnical community within ISSMGE.

Join the Movement

Young engineers and Member Societies are encouraged to continue supporting AYGEC 2026 and similar initiatives worldwide.

Registration remains open, and ISSMGE Member Societies are invited to sponsor young participants.

Organizer: Nigerian Institution of Geotechnical Engineers (NIGE)

<https://nige.org.ng>
conference@nige.org.ng

TC211: Technical Committee – Ground Improvement

Ground Improvement Techniques Photo Competition

Objective:

Capture and share innovative or informative ground improvement techniques in action. Showcase your best or interesting work in the field of ground improvement, and include a brief story associated with the photo.

Prizes:

- **First Place** 1000 Australian dollars
- **Second Place** 500 Australian dollars
- **Third Place** 250 Australian dollars
- **All Participants:** Once finalized, all participants will receive a digital copy of the booklet featuring selected entries.

Submission Deadline:

- All entries must be received by 31 May 2026, 11:59 PM GMT.

Eligibility:

Open to all, with the conditions that participants agree to: Winners will prepare a short write up, around 500 words, for the ISSMGE Bulletin (a brief "story behind the photograph," plus any relevant reflections).

Grant ISSMGE the right to use and disseminate their photographs without restriction. The names and affiliations of the providers will be acknowledged.

Participants must have been directly involved in the project depicted in the submitted photo. Please note that images generated using Artificial Intelligence (AI) tools are not eligible for submission.

Photo Submission Criteria:

- Photos must clearly depict a ground improvement technique (e.g., surface compaction, deep compaction, grouting, earth reinforcement, deep soil mixing, vertical drains, vacuum preloading, stone columns, rigid inclusion, chemical modification, bio-cementation soil stabilization, ground freezing, thermal treatment, geosynthetic reinforcement, cut-off walls and permeable trenches, relevant laboratory testing or similar projects).
- High-resolution images only (minimum 300 dpi).
- Each photo must be accompanied by a description of up to 150 words explaining the technique shown, its significance, location, and the impact or outcome of the project.

How to Enter:

- Submit your technical photo and accompanying description (name, affiliation, contact details) via email to TC211 Secretary, Ms Fanny Maucotel at fanny.maucotel@menard-mail.com
- File format: JPEG or PNG for photos; PDF or Word document for the description.
- Include your full name, position, professional affiliation (institution, organisation, company or university), and contact information in the email.

Judging Criteria:

- Relevance and clarity of the ground improvement technique depicted.
- Visual impact and quality of the photo.
- Creativity and insight in the accompanying description.

Announcement of Winners:

- Winners will be announced on 30 July 2026 via ISSMGE website and email notification.

Contact:

For any questions or further information, kindly contact:

- Ms Fanny Maucotel at fanny.maucotel@menard-mail.com



News

<https://www.isrm.net>

Colombo, Sri Lanka, July 10, 2026 - The Second ISRM Commission Conference on Estimation of Rock Mass Strength and Deformability 2026-02-06

The Sri Lankan Rock Mechanics and Engineering Society (SLRMES) invites you to participate in the [Second ISRM Commission Conference on Estimation of Rock Mass Strength and Deformability](#), to be held in Renuka City Hotel, Colombo, Sri Lanka, on 10 July 2026.

A call for Abstracts, Exhibitors, and Sponsors for the conference is now being released. [Please click here for the leaflet.](#)

53rd ISRM Online Lecture will be given by Dr Mark Diederichs from Canada in March 2026-02-14

The 53rd ISRM Online Lecture will be given by Dr Mark Diederichs, from Canada, and the title is "**Putting Geology Back in the Numbers – The Role of Engineering Geology in Rock Engineering and Risk Mitigation**". Go to <https://isrm.net/page/show/1104> to know more.



News

<https://about.ita-aites.org/news>

ITACET Lunchtime Lecture Series #53 10 February 2026

Join us for the next LLS on February 10!

This instalment of the Lunchtime lecture series will focus on 'Recent international developments in life cycle management of underground assets' in collaboration with WG 21 and will finish with a Q&A session with all speakers.

- Infrastructure tunnel management: Principles, strategies, and informed decisions – Leo Mc Kibbins
- Recommendations on life cycle costing of tunnels – Urs H. Grunicke
- The Netherlands: Cross-sector learnings for smart sustainable asset management – Paul Van Kempen

Register here : [Lunchtime lecture series#53 - ITACET](#)

Call for Nominations — Walter Grantz Memorial Award 12 February 2026

Following the fourth presentation of the Walter Grantz Memorial Award in Stockholm—awarded to Arne de Jong—ITA Working Group 11 invites nominations for the 2026 edition. The award recognises outstanding young engineers in immersed tunnelling, with the presentation to take place at WTC 2026 in Montréal.

About the award

The Walter Grantz Memorial Award commemorates Walter Grantz, a devoted member of WG 11 for nearly three decades. The award recognises a young engineer (guideline: under 35) who has (i) made a strong contribution to WG 11, (ii) carried out research in the immersed tunnel field, or (iii) con-

tributed notably to an immersed tunnel project. The prize includes a certificate and a monetary award equivalent to the WTC registration fee, to support the winner in presenting their work at the congress and/or within WG 11 meetings. *(Travel costs are not included.)*

Who can be nominated

Candidates are typically put forward via WG 11 country representatives and should meet one or more of the following:

- Substantive WG 11 contribution
- Recognised research in immersed tunnelling
- Notable project contribution in immersed tunnelling Jury and presentation

Nominations are assessed by a panel comprising the Animateur, Vice-Animateur, Past (Vice-)Animateur and the WG 11 Tutor. The award will be presented during the WG 11 meeting at WTC 2026 in Montréal.

How to nominate

1. Complete the nomination form (criteria included)
2. Submit by: 21 February 2026
3. Where to send: secretariat@ita-aites.org
4. Questions: contact your WG 11 country representative or the WG 11 secretariat: secretariat@ita-aites.org

Note for nominators: If the eventual awardee intends to present at WTC, abstract/paper submission remains subject to the congress' official deadlines and acceptance process.

Media contact:

WG 11 Chair — m.thart@tec-tunnel.com +31 6 2722 9289

Download: [Nomination form \(PDF\)](#)

Scooped by ITA-AITES #143, 9 February 2026

[Hong Kong drainage tunnel tender issued | China](#)

[HS2: Porous Portals Completed on Northern End of Chiltern Tunnel | UK](#)

[Grand Paris Express Line 15 West Lot 2 TBM accepted | France](#)

[From Milan Metro to Gotthard Tunnel: 5 Materials Science Feats](#)

[Govt remains open to fourth cross-harbour tunnel | China](#)

[Dubai Loop vs Glydways: Which one will fix Dubai's traffic jams better? | UAE](#)

[Major milestone for Snowy Hydro as work on 'cutting-edge' project continues | Australia](#)

[MetroLink: Bidding process for construction contracts worth €7.9bn begins | Ireland](#)

[Bullet Train Hits Milestone With Palghar Tunnel Breakthrough | India](#)

[Southern Hemisphere's largest TBMs readying for final push under Sydney Harbour | Australia](#)

Scooped by ITA-AITES #144, 24 February 2026

[Doors open between last two sections of Scheldt Tunnel | Belgium](#)

[M3 motorway tunnelling breakthrough | UK](#)

[Montreal blue line extension starts excavation with giant tunnel boring machine | Canada](#)

[Manual TBM for Southampton Link Main: design and constructability notes for engineers | UK](#)

[Siliguri Chicken's Neck underground railway | Underground railway line plan, 33.76km-long project in 'Chicken's Neck' area | India](#)

[Singapore LTA awards contracts for DTL2e stations](#)

[Egypt: Studies Advance to Extend Alexandria Metro Network](#)

[2026 U.S. Tunnel Industry Outlook](#)

[India's First Underwater Road-Cum-Rail Tunnel under Brahmaputra River Approved | India](#)

siderations and lessons learned from working in pressurised environments. The session will also highlight innovative approaches for air injection and its role in supporting safe tunnel construction.

Josh Knight

Josh is the Tunnel Agent for Balfour Beatty VINCI working on the HS2 Bromford Tunnels. He managed the completion of the TBM tunnel drive which broke through in May 2025, and is now managing the Cross Passage works. Prior to HS2 Lots N1 & N2, he worked on Tideway East and Hinkley Point C.

Emrah Simdi

Emrah is the Engineering Manager at Balfour Beatty VINCI, leading engineering delivery team for the HS2 Bromford and Long Itchington Wood tunnels. He has 20 years' experience delivering major tunnelling and underground infrastructure projects across the UK, Turkey, and the Middle East

[Registration Link](#)



February Lecture

Compressed Air Working at HS2 Bromford Tunnel

Thursday, 19th February 2026, 18:00 - 19:30 GMT
ICE QH, One Great George Street, London, SW1P 3AA



Event Information

This BTSYM lecture will explore compressed air (hyperbaric) works undertaken on HS2's 5.7 km twin-bore Bromford Tunnels constructed using 8.62m diameter Variable Density TBMs.

The presentation will focus on the key challenges, safety con-



www.geosyntheticssociety.org

News

[IGS Elections Now Open: President, Vice President, and Council \(Plus a Member Survey!\)](#) February 2, 2026

Elections for IGS President and Vice President are now underway. Three candidates are standing for President and two candidates are standing for Vice President. Twenty [Read More >>](#)

[Quick Interview: IGS Award & DEI Mentorship Initiative](#) February 12, 2026

In this short video, Guilia Lugli interviews Erol Guler, both leaders from the IGS Diversity Committee as they share insights into the Society's commitment to [Read More >>](#)

[Contenders Needed For Africa-Middle East Corporate Case Study Heat](#) February 13, 2026

Got a geosynthetics project in Africa or the Middle East that deserves global acclaim? Enter the IGS Corporate Case Study Competition for this region for [Read More >>](#)

[An Interview with TechFab India Managing Director: Mr. Anant Kanoi](#) February 16, 2026

This article is part of a Premium Corporate Member spotlight, providing Premium Corporate Members with the opportunity to showcase their history, work and products. It [Read More >>](#)

[Company History: TechFab India Industries Ltd.](#) February 17, 2026

This article is part of a Premium Corporate Member spotlight, providing Premium Corporate Members with the opportunity to showcase their history, work and products. It does [Read More »](#)

[TechFab India Case study: When Ground Engineering Shapes a National Icon](#) February 20, 2026

This article is part of a Premium Corporate Member spotlight, providing Premium Corporate Members with the opportunity to showcase their history, work and products. It [Read More »](#)

[Craig Benson to Give Kerry Rowe Lecture](#) February 24, 2026

Cutting-edge research on the behavior of bentonite in geosynthetic clay liners will be shared on the global stage after emeritus academic Craig Benson has been [Read More »](#)



News

www.britishgeotech.org/news

The January/February 2026 issue of Ground Engineering is available on line 12.02.2026

The December 2025 issue of Ground Engineering is available on line. Online access to Ground Engineering (GE) is included in BGA subscriptions. [Read More](#)

The March 2026 issue of Ground Engineering is available on line 12.02.2026

The December 2025 issue of Ground Engineering is available on line. Online access to Ground Engineering (GE) is included in BGA subscriptions. [Read More](#)

BGA Supports GE GeoTech 2026 – Member Discount Available 26.02.2026

BGA Supports GE GeoTech 2026 – Member Discount Available [Read More](#)

ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

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

2nd International Symposium on Tailings Storage Facilities, March 11 to 13, 2026, Hermosilo, Sonora, Mexico, <https://2sisdij-hermosillo-2026.com.mx/en/index.php>

Observational Method Conference Perspectives and feedback from academics, consultants, contractors, clients, and technical committees, 17 Mar 2026, London, United Kingdom www.omconference2026.com

GEOMOS26 2nd International Scientific and Practical Conference on Soil Mechanics, Geotechnics and Foundation Engineering INTELLIGENCE ON GUARD OF MECHANICAL SAFETY, March 17-20, 2026, Moscow, Russia, <https://geomos.rssmgfe.ru/en/>

3rd Annual Conference on Foundation Decarbonization and Re-use, March 24-26 2026, Amsterdam, The Netherlands <https://foundationreuse.com>

3rd Annual Conference on Foundation Decarbonization and Re-use, March 24-26 2026, Amsterdam, The Netherlands, <https://foundationreuse.com>

Basements and Underground Structures Beneath the Surface, Beyond the Future, 24 March 2026, London, United Kingdom, <https://baseents.geplus.co.uk/GEBA2026/en/page/home>

PMGEC LEBANON 2026 Pan Mediterranean Geotechnical Engineering Conference, 25 - 28 March 2026, Phoenicia Bei-rut IHG, Lebanon <https://pmgtec-leb.com>

Sixth International Conference on Geotechnical Engineering – Iraq (6ICGE-Iraq 2026), April 8–9, 2026, Baghdad, Iraq, <https://icge-iraq.uobaghdad.edu.iq/>

3rd International Conference on Advances in Rock Mechanics (TuniRock 2026), 09-12 April, 2026, www.tunirock2026.com

International Conference on Geotechnics, Civil Engineering and Structures (CIGOS) 2026 Innovation in Planning, Design and Civil Infrastructure for Resilient and Sustainable Transformation, April 16 & 17, 2026, Ho Chi Minh City, Vietnam <https://cigos2026.sciencesconf.org>

LANDSLIDES 2026 Landslide Geo-Education and Risk (LAGER), 27 April - 1 May 2026, Queenstown, New Zealand <http://landsliderisk.nz>



Deep Foundations & Underground Infrastructure Setting the Benchmark for Geotechnical Excellence in the Middle East 4 - 5 May 2026, Dubai, UAE <https://deepfoundationsmena.com>

Now entering its third consecutive year, the **Deep Foundations & Underground Infrastructure MENA Conference (DFUI 2026)** has solidified its position as the region's most influential platform for advancing geotechnical excellence and underground construction innovation. Returning on **4–5 May 2026** in **Dubai**, the conference continues to unite project owners, engineering consultants, contractors, solution providers, and policymakers to address the increasingly complex subsurface challenges shaping the Middle East's infrastructure landscape.

As the region accelerates groundbreaking megaprojects, ranging from metro and rail expansions to large-scale tunneling works, utility corridors, water drainage systems, and next-generation industrial zones; the need for robust, data-driven, and future-ready deep foundation solutions has never been more critical.

The 3rd Annual DFUI Conference offers unparalleled opportunities to explore cutting-edge technologies, share real-world case studies, and engage in high-level discussions on design, safety, risk mitigation, digital transformation, and geotechnical engineering best practices tailored to the MENA region's demanding soil conditions. Building on the success of previous editions, DFUI

DFUI 2026 Themes

2026 will focus on five strategic themes that reflect the region's evolving underground engineering needs:

- Advanced Ground Improvement and Rapid Construction Techniques
- Integrated Geo-Structural Modelling and Adaptive Design
- Urban Tunneling and Strategic Underground Space Optimization
- Climate-Resilient Geotechnical Design and Subsurface Adaptation
- Predictive Geotechnical Risk Intelligence and Proactive Mitigation

Get in touch

- Daytona House, Motor City Dubai UAE
- +971 4 568 7800
- info@qmevents.ae



15th International Conference "Modern Building Materials, Structures and Techniques", May 12-15, 2026, Vilnius, Lithuania, <https://vilniustech.lt/332107>

ITA-AITES WTC 2026 World Tunnel Congress, May 15 to 21, 2026, in Montreal, Quebec, Canada, <https://wtc2026.ca>

94th Annual Meeting & International Symposium on Large Dams - Water, Energy and Society: The Evolving Role of Dams in a Changing World, May 21 to 29, 2026, Guadalajara, Mexico, www.icoldmexico2026.com

Summer School on AI Tools for Structural and Earthquake Engineering, June 1st – 5th 2026. Guimarães, Portugal. Please confirm your participation at sec.estru-turas@civil.uminho.pt by February 28th.

ICPMG 2026 Physical Modelling in Geotechnics, 8–12 June 2026, ETH Zürich, Switzerland, <https://tc104-issmge.com/icpmg-2026>

8th International Young Geotechnical Engineers Conference - 8YGE, 11. - 14. June 2026, Graz, Austria, www.tugraz.at/institute/ibg/events/8iygce

21st International Conference on Soil Mechanics and Geotechnical Engineering Geotechnical Challenges in a Changing Environment, 14 – 19 June 2026, Vienna, Austria, www.icsmge2026.org/en

3rd International Geotechnical Innovation Conference - Shaping the World Beneath: Fostering Sustainability, Innovation and Resilience in Geotechnics, 15 - 16 June 2026, Jeddah, Saudi Arabia, <https://geotechnicalinnovationconference.com> Email info@creativeconnectionevents.com

ICONHIC 2026 International Conference on Natural Hazards & Infrastructure, 29 June – 2 July 2026, Chania, Greece <https://iconhic.com/2026>

Summer School - Numerical Modelling in Geotechnical Engineering, 06-10 July 2026, Innsbruck, Austria, www.uibk.ac.at/en/weiterbildung/numerische-modellierung

International Summer School "Risk Management of Monuments subjected to Geohazards and Climate Change", 20 - 24 July 2026, Karlovasi, Samos, Greece, www.edusamos.gr

ISFMG 2026 12th International Symposium on Field Monitoring in Geomechanics, 06 -10 August 2026, Indian Institute of Technology Indore, India, <https://sites.google.com/view/isfmg2026/home>

Soft Soils 2026 International Conference on Advances and Innovations in Soft Soil Engineering 2026, 24-26 August 2026, Delft, Netherlands <https://softsoils2026.dryfta.com>

ICGE Colombo 2026 4th International Conference on Geotechnical Engineering, 24-26 August 2026, Colombo, Sri Lanka, <https://icgecolombo2026.org/>

X Latin American Congress on Rock Mechanics 26 - 28 Aug, 2026, Brsasilia, Brazil, <https://larms2026.com>

CREST 2026 3rd International Conference on Construction Resources for Environmentally Sustainable Technologies, Sep 07-08, 2026, Cambridge, England-United Kingdom <https://engage-events.ifm.eng.cam.ac.uk/IC-CREST2026/#/>

13 ICG - 13th International Conference on Geosynthetics (13 ICG), 13-17 September 2026, Montréal, Canada, www.13icg-montreal.org

Scientific Colloquium: Large Scale Testing 2026, 14-15 September 2026, Karlsruhe, Germany, www.ibf.kit.edu/908.php

Eurock 2026 Risk Management in Rock Engineering - an ISRM Regional Symposium, 15-19 September 2026, Skopje, Republic North Macedonia, <https://eurock2026.com>

ECEE2026 18th European Conference on Earthquake Engineering Shaping the Future of Earthquake Engineering, 14 – 1 September 2026, Berlin, Germany, <https://ecee2026.eu>

ISRM Regional Symposium – EU-ROCK 2026, September 15–19, 2026, in Skopje, N. Macedonia, <https://eurock2026.com>

4th International Symposium Preservation of Monuments & Historic Sites, 16 – 18 September 2026, Athens, Greece <https://tc301-athens.com>

2nd International Conference on Insitu Measurement of Soil Properties and Case Histories INSITU 2026, September 21 - 23, 2026, Bali, Indonesia <https://www.insitu2026.com/>



01 October 2026, London, United Kingdom
<https://geotech.geplus.co.uk/geotech2026/en/page/home>

About the Conference

Experience a dynamic day of knowledge-sharing, insightful discussions and industry-leading expertise at the GeoTech.

GeoTech will move beyond a traditional conference. With an exciting programme running across multiple event stages, featuring insightful content and immersive activities, GeoTech will enable delegates to customise their own agenda and discover the topics and subjects that are of most interest to them.

The event's open floor plan and short content sessions interspersed with multiple networking breaks will give maximum opportunities to learn, share ideas, build connections and be part of the action.

Bringing together decision-makers, contractors and supply chain professionals, this immersive event features inspiring - keynotes, expert panel discussions and real-world case studies from groundbreaking projects shaping the future of geotechnics.

Themes and Topics

Innovations in design and construction risk management

- Advancements in site investigation techniques
- Innovations in geotechnical soil testing
- New approaches to assessing geotechnical risks
- Smart data usage in design
- Optimising foundation design using advanced geotechnical data
- Advances in geotechnical modelling

Advancements in construction approaches and project delivery

- Innovative ground improvement techniques
- Use of robotics and automation

- Sustainable and resilient construction practices
- Innovation or new technologies in plant or piling equipment

Extending asset life and efficient maintenance

- Advances in remote sensing and geotechnical monitoring
- AI and data-driven decision-making for risk management
- Sustainable engineering techniques for slope stabilisation
- Case studies: Lessons learned from recent projects
- Regulatory considerations and industry best practices

Event enquiries

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6th International Conference on Information Technology in Geo-Engineering JTC2 Conference, 13-16 October 2026, Graz, Austria, www.icitq2026.com



Adapting to change ~ Embracing opportunities 14-16 October 2026, Bologna, Italy

We are pleased to announce that the HYDRO 2026 conference and exhibition will take place in Bologna, Italy from 14 to 16 October 2026, with the overall theme 'Adapting to change ~ Embracing opportunities'.

The Call for Papers brochure can be found on our website here. We welcome abstracts on any of the topics listed in the brochure, or related topics, as soon as possible and by 16 March 2026 at the latest. Please make sure to follow the guidelines on the final page of the brochure when submitting an abstract - thank you.

A brief initial report of the previous event in this series, HYDRO 2025, held recently in Thessaloniki, Greece is available on our website here. A more detailed report will be published soon in Hydropower & Dams journal.

For any enquiries about the HYDRO 2026 conference programme, please contact us at: Hydro2026@hydropower-dams.com

For enquiries about the HYDRO 2026 Exhibition, please contact: Sales@hydropower-dams.com

More information about HYDRO 2026 will be uploaded to a dedicated part of our website soon, and then this micro-site will be regularly updated in the coming months. Meanwhile, please mark the dates in your calendar for next year, and we hope to welcome you in Bologna.



EWRWSE – 2026 7th International Conference on Environmental Geotechnology, Recycled Waste Materials and Sustainable Engineering, 22-25 October 2026, Surat, Gujarat, India www.eqrwse2026.com

SLOPE STABILITY 2026 Slope for Safety Performance an ISRM Specialized Conference, 26 – 29 October 2026, Lima, Peru www.slopestability2026.com/en

PBD-V Chile International Conference on Performance-Based Design in Earthquake Geotechnical Engineering, November 4th to 6th, 2026, Puerto Varas, Chile www.pbd-v-chile.com

ARMS 14 Fukuoka 2026 - 14th Asian Rock Mechanics Symposium Rock Mechanics for the Next Generation –Innovations, Sustainability, and Resilience – an ISRM Regional Symposium, 22-26 November 2026, Fukuoka, Japan, www.ec-convention.com/ARMS14/

GEOTEC HANOI 2026, The 6th International Conference on Geotechnics for Sustainable Infrastructure Development, November 26 - 27, 2026, Hanoi, Vietnam, <https://geotechn.vn/>

5th International Conference on TRANSDISCIPLINARY MULTISPECTRAL MODELLING AND COOPERATION FOR THE PRESERVATION OF CULTURAL HERITAGE Cultural heritage at the forefront of transformation, 14-16 December, Athens, Greece, www.tmm-ch.com

7th International Conference on Grouting and Deep Mixing, March 17 - 19, 2027 | Florence, Italy, <https://dfi-events.org/grout27/index.html>

GeoMandu 2027, 11th AYGEC and 1st SACG Mountain Geotechnics for Infrastructure Development Redefining Geotechnics for the Mountainous Landforms, 17-19 March 2027, Kathmandu, Nepal, <https://geomandu.ngeotechs.org>

IS-GI LYON 2026 International Symposium on Ground Improvement, April 12 to 14, 2027, Lyon, France, www.menard-group.com/isgi-lyon2027



**ITA World Tunnel Congress 2027 - Antwerp
(WTC 2027)
Underground Creativity to Meet Societal Needs
23-29 April 2027, Antwerp, Belgium
<https://wtc2027.com/>**

The World Tunnel Congress 2027, scheduled to take place in Antwerp from the 23rd to the 29th of April 2027, is a leading event in the field of tunnel construction, underground building, and technology. Professionals from around the world gather to exchange knowledge, present innovations, and discuss the future of the tunnel industry. The event attracts experts, researchers, policymakers, and companies from various sectors, including civil engineering, construction, transportation, and infrastructure.

Plenary Session – Opening Ceremony

The World Tunnel Congress will commence with an official Opening Ceremony that marks the beginning of a week dedicated to knowledge exchange and professional collaboration. The ceremony will feature the distinguished Muir Wood Lecture, delivered by a leading figure in the tunnelling field, alongside keynote presentations addressing current challenges and innovations in underground construction. The Muir Wood Lecture named in honour of Sir Alan Muir Wood (1921–2009), one of the founding figures of the ITA and a highly respected civil engineer who made major contributions to tunnelling and underground construction worldwide.

Parallel Technical Sessions

The Parallel Technical Sessions form the core of the ITA World Tunnel Congress technical program, providing a platform to present and discuss the latest research, projects, and innovations in tunnelling and underground space development. Organised across multiple thematic tracks, these sessions allow participants to choose detailed topics that best fit their professional interests and expertise.

Covering a wide range of subjects—from design and construction techniques to sustainability, safety, digitalisation and contractual practices—the sessions encourage in-depth exchange of knowledge and foster collaboration among industry professionals worldwide.

To maximise direct engagement and knowledge sharing, the program will emphasise a dynamic oral format, featuring both long and short presentations and workshops. This year's congress prioritises these verbal exchanges across all thematic tracks in lieu of a traditional poster gallery, ensuring every selected work has a dedicated moment for audience interaction.

TOPICS

ITA WTC2027 will cover a broad range of topics shaping the future of tunnelling and underground space. The 12 main topics listed below structure the technical programme.

T1-6 - Advancements in design, engineering & construction technologies

Advancements in underground construction are significantly influenced by ongoing research and development of new technologies, alongside with strong collaboration between all project participants and the users. Through continuous R&D and effective teamwork, the industry can achieve enhanced performance and reliability.

T1 – Conventional tunnelling

T2 – Mechanised tunnelling

T3 – Immersed tunnels

T4 – Complex geometries, including shafts and ramps

T5 – Investigations and ground characterisation

T6 – Instrumentation and monitoring

T7 - Sustainable & resilient underground construction

Sustainable and resilient underground construction focuses on minimising environmental impact while ensuring long-term durability and adaptability. Efficient resource use, innovative design approaches, and robust construction methods contribute to tunnels and underground spaces that can withstand changing conditions and future demands.

T8 - Urban underground development & innovative uses of underground spaces

Urban underground development is increasingly seen as a solution to growing cities facing limited surface space. By utilising the underground environment, cities can create multifunctional spaces that support urban growth, enhance sustainability, provide secure storage, and improve quality of life, while reducing congestion and minimising the impact on the natural landscape.

T9 - Safety and risk mitigation

Minimising hazards, enhancing structural integrity, and improving emergency preparedness. Advances in design, construction methods, and operational strategies help reduce risks for workers and users. Improved safety standards, regulatory frameworks, and proactive risk management approaches ensure that tunnels remain secure, resilient, and reliable throughout their lifecycle.

T10 - Operation, inspection, monitoring and refurbishments

As cities evolve, repurposing existing underground spaces offers sustainable and cost-effective solutions for modern infrastructure needs. Advances in engineering, materials, and architect's involvement enable the seamless integration of existing structures with new functions, unlocking full potential of underground infrastructure and minimising environmental impact.

T11 - Innovation in tunnelling: Digital transformation & smart tunnelling solutions

The integration of digital technologies in tunnelling is revolutionising project delivery. Solutions like BIM, digital twins, IoT and AI optimise the works, ensuring that underground infrastructure meets the demands of future urbanisation and transportation networks.

T12 - Economic viability: financing, cost- optimisation, and long-term value

This topic explores financial strategies for tunnel projects, including financing models, contract models, cost management, and lifecycle investment returns. It examines how to balance initial construction costs with long-term operational efficiency to ensure economic sustainability.



The Young Members session at the World Tunnel Congress provides a dynamic platform for early-career professionals and students to share their ideas, research, and experiences within the tunnelling and underground space industry. These sessions foster dialogue between emerging talents and established experts, encouraging mentorship, innovation, and collaboration across generations.

ITACET Training Course

This two-day training course is organised by the Local Organising Committee of ITA WTC2027 and endorsed by the ITA-CET Foundation and ITA-CET Committee.

This year we will focus on the congress theme "Underground Creativity to Meet Societal Needs." Over two days, participants will explore key aspects of tunnelling in urban environments, guided by leading national and international experts.

The course will centre on a comprehensive case study, allowing participants to examine multiple stages of a tunnelling project—from design and construction to operation and maintenance.

Through interactive workshops, attendees will develop practical solutions under expert supervision and will have the opportunity to present and exchange their ideas with professionals active in those roles.

The program will also include a short technical site visit in Antwerp, offering valuable real-world context.

A detailed schedule will be announced at a later date.

[23-24 April 2027 training course](#)
[25 April 2027 site visit](#)

[Venue: A Room with a Zoo](#)

Please note that registration for the ITACET Training Course is independent of the full congress, participation in the training course does not require congress registration.

Contact us

Have you any questions or need more information about ITA World Tunnel Congress 2027?

Our team is here to help. Reach out to us via email or phone, and we'll be happy to assist you with exhibition, sponsorship, registration, program details, or any other inquiries.

Email: wtc2027@aimgroup.eu

Phone: +32 2 722 82 39



International Symposium Cone Penetration Testing CPT '27, May 12 - 14 2027, Vancouver, Canada, www.cpt27.org

XVIII DECGE Danube-European Conference on Geotechnical Engineering, 9-12 June 2027, Budapest, Hungary, <https://18decge.hu/>

11th European Conference on Numerical Methods in Geotechnical Engineering, 21 - 24 September 2027, Graz, Austria, www.tugraz.at/events/numge2027/home

16th International Congress on Rock Mechanics Innovations in Rock Mechanics and Rock Engineering for a Sustainable Future, 17-23 October 2027, Seoul, Korea, <https://isrm2027.com>

10th ISSMGE International Congress on Environmental Geotechnics, 01-04 November 2027, Kyoto, Japan, <https://10iceg.org>



**Eurock2028 -
Advances in rock mechanics and rock engineering to cope with increasingly extreme conditions - an ISRM Regional Symposium
25 - 30 Jun, 2028, Aix-en-Provence, France**



ECSMGE 2028
XIX. EUROPEAN CONFERENCE ON SOIL MECHANICS AND
GEOTECHNICAL ENGINEERING

"Connecting Continents Through Geotechnical Innovations"
04-08 September 2028, Istanbul, Turkey
<https://zmqm.org.tr/en>

Conference Topics

- 01 Modelling and Experimental Assessment of Geomaterials
- 02 Geohazards, Earthquakes and Risk Mitigation
- 03 Development of Resilient and Sustainable Geosystems
- 04 Geotechnical Construction and Soil Improvement
- 05 Geotechnical Engineering of Multiscale Observations, Sensors and Monitoring
- 06 Energy Geotechnologies
- 07 Technological Innovation
- 08 Geo Education, Standards And Codes

Contact

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GeoEng 2030: Bringing Together the Global Geo-Engineering Community, geoeng2030@geosyntheticssociety.org.

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΓΕΩΛΟΓΙΑ

The 2 February 2026 landslide on the Ionian motorway between Arta and Amfilochia

An unusual failure has occurred on a cut slope adjacent to a key road in Greece.

On 2 February 2026 a major, fascinating landslide occurred on the A5 Ionian motorway between Arta and Amfilochia in Greece. The location appears to be [39.07754, 21.09861]. [The news site ekathimerini has a story providing the details, which includes this extraordinary image of the aftermath of the landslide:-](#)



The 2 February 2026 landslide on the Ionian motorway in Greece. [Image from ERT via ekathimerini.](#)

I believe that the Google Earth image below shows the configuration of the site in 2023:-



Google Earth image showing the site of the 2 February 2026 landslide on the Ionian motorway in Greece.

So, this is a large cut slope that appears to have been formed in about 2015 (based on Google Earth imagery). The failure is quite complex, with most of the landslide moving as a large block (which has fractured in the late stage of movement). There is a large displacement on the far side of the landslide (in the photograph view), so there has been some rotation around an approximately vertical axis. The landslide does not appear to have been conventionally rotational.

To me, this suggests failure on an existing plane of weakness in the slope. The news report indicate that the landslide occurred after heavy rainfall.

This is a Google Streetview of the landslide site from September 2023:-



Google Streetview image showing the site of the 2 February 2026 landslide on the Ionian motorway in Greece.

It appears that the slope has rockbolts, which suggests that there was an awareness of the potential for instability. Perhaps they were insufficiently long to prevent this failure? The presence of the rockbolts may explain why the landslide moved as a predominantly intact block, though.

The Ionian motorway is now closed. There are similar slopes along the road, so the investigation of this failure may have wider implications.

(Dave Petley / Eos – THE LANDSLIDE BLOG, 3 February 2026, <https://eos.org/thelandslideblog/ionian-motorway-1>)



The massive, developing gully at Pondok Balik in Indonesia

A massive gully has been developing over the last two decades at Pondok Balik. It now covers an area of over 3 hectares.

In Indonesia, a massive and rapidly developing gully is causing considerable concern. Located at Pondok Balik in Central Aceh Regency, Aceh province, this feature has been developing since 2004. [Reuters has an excellent gallery of images that is worth a view. There is a really good summary of the history of this gully on The Watchers website too.](#)

[There is some nice drone footage of this feature in this SindoNews report on Youtube:-](#)



<https://eos.org/thelandslideblog/pondok-balik-1>

The location of this very large gully is [4.72374, 96.73117]. This is a Google Earth image of it, captured in June 2025:-



Google Earth image from June 2025 of the massive gully at Pondok Balik in Indonesia.

By comparison, here is an image from February 2015:-

The gully is reportedly developing in loose volcanic materials, which are prone to rapid erosion when disturbed and saturated. In Indonesia, rainfall totals are high.

There are concerns about potential damage to the road seen in the image and to high voltage electricity pylons running through the area. It is proposed to seek to manage the hazard by reinforcing the soil and managing surface and subsurface water. This will not be straightforward or cheap.



Google Earth image from February 2015 of the massive gully at Pondok Balik in Indonesia.

(Dave Petley / Eos – THE LANDSLIDE BLOG, 17 February 2026, <https://eos.org/thelandslideblog/pondok-balik-1>)

ΝΕΕΣ ΕΚΔΟΣΕΙΣ ΣΤΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΠΙΣΤΗΜΕΣ



Austroads has released new technical specifications to support best practice in the construction and maintenance of road and transport infrastructure.

These specifications provide clear requirements for earthworks, stormwater infrastructure, traffic facilities, and safety barriers, helping practitioners deliver safer, more durable, and efficient projects.

The Austroads Earthworks and Stormwater Specifications include:

- [ATS-2135-25 Management of Acid Sulfate Soils](#)
- [ATS-2170-25 Geosynthetic Reinforcement](#)
- [ATS-2180-25 Dry Deep Soil Mixing](#)
- [ATS-2185-25 Concrete Injected Columns](#)
- [ATS-2240-25 Construction of Stormwater Infrastructure](#)

Updated Specification: Microtunnelling and Auger Boring

Austroads Technical Specification ATS 4541 sets out the requirements for the installation of pipes by Microtunnelling or Auger Boring, which are types of trenchless technology that are launched from an excavated pit. The pipes may be for the purpose of moving fluids or gases or for the protection of telecommunications/electrical cables.



GEO-TRENDS REVIEW

Issue #34 - February 2026

www.mygeoworld.com/geotrends/issues/34-february-2026

Now is a good time to review your draft abstract.
[International Journal of Geoengineering Case Histories Journal](#) 20 Feb 2026 [Read More](#)

Landslide and Rockfall Risk Reduction in Baspa Valley, Himachal Pradesh: Science Based Solutions for Safer Communities and Responsible Governance
[Ashutosh Kainthola](#) 09 Feb 2026 [Read More](#)

ISSMGE Interactive Technical Talk Episode 29: Geotechnical Infrastructures for Megacities and New Capitals (TC305)
[ISSMGE ITT29](#) 08 Jan 2026 [Read More](#)

The Swelling Pressure of Expansive Soils Compacted at Various Moisture Contents Relative to the Optimum Moisture Content (OMC)
[Moses Archer Mensah](#) 11 Feb 2026 [Read More](#)

Sixth International Conference on Geotechnical Engineering Iraq (6ICGE-Iraq 2026)
[Mahdi Karkush](#) 02 Jan 2026 [Read More](#)

Landslide at Cebu City landfill kills one, exposes waste slope stability risks
[Geoengineer.org news](#) 10 Jan 2026

A fatal landslide struck the Cebu City landfill in Barangay Binaliw on January 8, 2026, claiming the life of one landfill worker and injuring several others. [Read More](#)

Joint Young Members Austria: A Year of International Connection, Innovation, and Preparations for 2026
[ISSMGE Young Members](#) 22 Jan 2026

The Joint Young Members Austria (J-YMA) look back on a landmark year in 2025, defined by strengthened international collaboration and a series of successful events. [Read More](#)

138,733 paper downloads in 2025 for the ISSMGE International Journal of Geoengineering Case Histories!
[Geoengineer.org news](#) 20 Jan 2026

The ISSMGE International Journal of Geoengineering Case Histories is proud to announce that its papers were downloaded 138,733 times in 2025 (up 18.32% from 117,260 downloads in 2024). [Read More](#)

In Memoriam: Profs Ishihara, Finn and Prakash
[ISSMGE](#) 12 January 2026

We recently lost three giants in the Earthquake Geotechnical Engineering profession, who TC203 would like to acknowledge. [Read More](#)

YII Envision Award Winner | GeoStruxer's digital twin cuts piles by 70% and CO2 by 44%
[Bentley Systems YII](#) 26 Feb 2026

Project: Securing critical food security infrastructure [Read More](#)

Check out our latest Geo-Short video!
[Geoengineer.org Geo-Short](#) 27 Feb 2026 [Read More](#)

The Annual Editorial Board Meeting of Indian Geotechnical Journal (IGTJ)
[Deepankar Choudhury IGTJ](#) 01 Jan 2026 [Read More](#)

Geotechnical Stability Analysis of Retaining Walls
[Geoengineer.org Retaining Walls](#) 26 Feb 2026
The geotechnical stability of a retaining structure is assessed using limit equilibrium methods, which determine the ratio of available resisting forces/moments to the driving forces/moments. [Read More](#)

Technical day on swelling soils
[Mounir Bouassida](#) 17 Feb 2026 [Read More](#)

44th Annual Geosystems Engineering Distinguished Lecture - Registration is open!
[UC Berkeley Geosystems Group Lecture](#) 27 Feb 2026 [Read More](#)

A Future Geologist
[Aboalgasem Alakhdar](#) 10 Jan 2026
My son, a future geologist the passion for exploring rocks begins in childhood [Read More](#)

ISSMGE Interactive Technical Talk Episode 28: Forensic Geotechnical Engineering (TC302)
[ISSMGE ITT28](#) 31 Dec 2025 [Read More](#)

Influence the Geotechnical Confidence Index Results for 2026 Q1!
[GeoWorld Learn more](#)

"Effect of application of Geogrid on optimization of Bridge Abutments on open foundation."
[Smriti Koju Retaining Walls](#) 06 Jan 2026 [Read More](#)

2026 Berkeley Geosystems Graduate Students Resume Booklet Published!
[UC Berkeley Geosystems Group](#) 24 Jan 2026 [Read More](#)

Early Career Interests in Geotechnical Engineering
[Abba Bello Muhammad, GMNSE](#) 21 Feb 2026
I am a recent civil engineering graduate with a strong interest in geotechnical and geo-environmental engineering. [Read More](#)

Italy declares emergency after expanding landslide forces 1,500 evacuations in Niscemi
[Geoengineer.org news](#) 29 Jan 2026

Italy has declared a state of emergency across several southern regions after Cyclone Harry unleashed severe storms that triggered a large and still-active landslide in the Sicilian town of Niscemi, forcing the evacuation of at least 1,500 residents and causing widespread disruption. [Read More](#)



INTERNATIONAL
GEOSYNTHETICS
SOCIETY



February 2026

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

IGS Council Elections Are Open – Cast Your Vote

Elections for IGS President, Vice President, and Council are now underway. 3 candidates are standing for President, 2 for Vice President, and 20 candidates are contesting 10 open Council seats in this ballot cycle.

Eligible Individual and Corporate Members received their **voting email on 2 February 2026**, with a **reminder sent on 24 February 2026**. If you have not seen your ballot from UK Engage (@ukevote.uk), please check your inbox or spam folder, or contact the IGS Secretariat. Remember, Council votes are weighted — your first choice receives the highest number of points.

You are invited to complete a brief optional **satisfaction survey** about your IGS membership after submitting your ballot. This is the first Society-wide member survey and your feedback will help guide future activities to better serve you and the global membership.

Voting closes at 11:59 PM CDT on Friday, 3 April 2026. [View candidate profiles here](#), cast your vote, and complete the short member survey included after the ballot to help shape the future of IGS.



Craig Benson to Deliver Prestigious Kerry Rowe



Lecture on Geosynthetic Clay Liners

Emeritus Professor **Craig H. Benson** will deliver the prestigious **Kerry Rowe Lecture** at the 13th International Conference on Geosynthetics, sharing his latest research on **bentonite behavior in geosynthetic clay liners (GCLs)**. His work explores how GCLs interact with aggressive leachates and innovations in bentonite-polymer composites, offering insights that could reshape the design of more durable, cost-effective liners worldwide. **Read more and register [here](#).**



[Register Now](#) For Blockbuster 13th ICG!

Organizer IGS North America has put together a rich programme of exclusive talks, courses, workshops and networking opportunities exploring the theme 'Legacy, Evolution & Revolution in Geosynthetics'. [Read the full article on our website.](#)

Premium Corporate Member Spotlight: TechFab India Industries Ltd.

This month, we showcased [TechFab India](#) as part of the [Premium Corporate Member offer](#). Explore the company's [history](#), read [an interview](#) with TechFab India Managing Director, Mr Anant Kanoi and discover [a case study](#) explaining how geosynthetic solutions reinforced soil walls and slope protection at the Statue of Unity in India.

These articles are part of a Premium Corporate Member spotlight, providing all Premium Corporate Members with the opportunity to showcase their history, work and products. It does not imply IGS endorsement of any products or services.

[Learn more](#) about the benefits of becoming a Premium Corporate Member.



IGS Committee News

IGS Awards & DEI Mentorship Initiative

Although this year's award nominations have now closed, we encourage members to watch the [IGS DEI video interview](#), which explains the renaming of the Young Member Award to

the **New Talent Award** and the thinking behind this change. The video also highlights the Society's ongoing **DEI Mentorship Initiative**, offering insight into the interviews and efforts underway to foster a more inclusive and representative global geosynthetics community.



<https://www.youtube.com/watch?v=uL1suvsK4Ms>

Africa-Middle East Regional Case Study Competition Now Open for IGS Corporate Members

The **IGS Africa-Middle East Regional Corporate Case Study Competition** is now open for submissions from IGS Corporate Members! This online competition highlights projects from Africa and the Middle East completed between December 2021 and June 2024. Shortlisted entries will present their work in a special online session in May 2026, with the winner advancing to the **Grand Finale at the 13th International Conference on Geosynthetics (13ICG)** in Montreal. Read all details [here](#).

Submission deadline: 30 April 2026. Don't miss this opportunity to showcase your innovative projects!



5th Workshop of IGS TC-Reinforcement & ISSMGE TC-218

The **5th Workshop of IGS TC-Reinforcement (TC-R)**, in collaboration with **ISSMGE TC-218**, will be held at Mediterranean University of Reggio Calabria, Italy, from **7-9 July 2026**. The workshop will focus on reinforced soil structures and geosynthetic solutions, with themes including seismic performance, sustainable backfills, case histories, construction practices, material developments, modelling, and design methods.

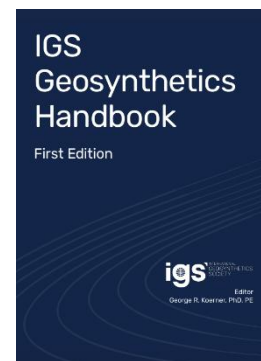
Members interested in contributing are invited to submit a tentative title and brief summary by **20th March**. Extended abstracts will be published in the workshop proceedings. You can find out more information [here](#) and register your interest [here](#).

IGS Geosynthetics Handbook Available To Buy Now

The long-awaited **IGS Geosynthetics Handbook** is now available to buy. A one-stop technical reference guide suitable for all levels of experience in geosynthetics. The handbook offers a concise yet comprehensive summary of the fundamental applications of geosynthetics and is an essential reference guide for student, instructor or civil engineering professional alike.

Non member price: \$200 USD
Member price: \$150 USD

IGS Chapters can access a bulk buy discount of 30 copies or more at \$75 USD per copy, for this option only, contact igssec@geosyntheticssociety.org.



Get Your Handbook Today

Upcoming Events

Explore the upcoming IGS events, industry events we will be attending and events delivered by IGS Chapters.

12 Mar 2026 IGS UK Webinar: The Value of Professional Inclusion Online, UK

Explores how Equity, Diversity and Inclusion (EDI) principles can strengthen workplace culture and the construction industry through practical, everyday actions. In this 45-minute session, Snéha Khilay of Blue Tulip Consultancy will discuss inclusive behaviours, language, and leadership approaches that help create respectful, collaborative environments where everyone can contribute fully. [Event page](#)

18 Mar 2026 NGO, IGS Netherlands: 2nd International Symposium Geosynthetics and Sustainability Environmental, Civil and Hydraulic Engineering Technical University Delft (TU Delft) Delft, Netherlands

The event will be held in person with a livestream option available, bringing together experts to explore sustainable geosynthetic solutions across engineering sectors. Register your attend on the event page below. [Event page](#)

30 Jun-02 Jul 2026 CEN TC 189 Meetings Copenhagen, Denmark

European standards committee meetings on geosynthetics, relevant for European practitioners and manufacturers. [Event page](#)

07-09 Jul 2026 5th Workshop of IGS TC-Reinforcement & ISSMGE TC-218 Mediterranean University of Reggio Calabria, Italy

The workshop will cover reinforced soil structures and geosynthetic solutions, including seismic performance, sustainable backfills, construction practices, and design methods. [Event page](#)

13-17 Sep 2026 13th International Conference on Geosynthetics Montreal, Canada

The conference theme, "**Legacy, Evolution & Revolution in Geosynthetics**," emphasizes innovation, sustainability, and global collaboration. Scheduled at the Palais des congrès de Montréal, attendees can access technical sessions, workshops, and networking opportunities. You can now register to attend at www.xcdsystem.com/icg. [Event page](#)

13-16 Oct 2026 6th International Conference on Information Technology in Geo-Engineering (6th ICITG)
Graz, Austria

The event explores digital innovations in geo-engineering, including BIM, monitoring, AI, and information modelling for engineering applications. [Event page](#)

2027

Sustainability Leads 5th GeoAfrica Conference Gauteng, South Africa

The 5th African Regional Conference on Geosynthetics (GeoAfrica 5) will take place in March 2027 at Misty Hills, Gauteng, South Africa. Hosted by IGS South Africa, the event will showcase sustainable geosynthetic solutions and innovations across infrastructure projects in Southern Africa. [Event page](#)

Join us at:



June 14-19 [21st Conference on Soil Mechanics and Geotechnical Engineering](#) – Vienna, Austria. A premier global forum for research, case studies and advances in geotechnical engineering and soil mechanics.

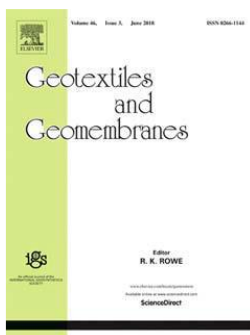


September 16-17 [Contamination & Land Remediation](#) – Birmingham, UK. Event dedicated to contaminated land, remediation technologies, water quality and environmental engineering solutions.

tal engineering solutions.



October 4-8 [International Water Association World Water Congress](#) – Glasgow, Scotland. A global water sector event covering policy, research, infrastructure, utilities, sustainability, and water governance.



Geotextiles and Geomembranes

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