



Gneiss News

Earth Club — Department of Earth Sciences

Date: September & October 2026 — **Editors:** Team Earth Club

A very warm welcome!

Welcome to the second edition of Gneiss News! Whether it's sensing microearthquakes with optical fibers, tracing climate shifts in the Central Himalayas, or rethinking animal origins, this issue is packed with exciting research highlights. We hope you enjoy reading it as much as we enjoyed putting it together!

Feel free to explore different sections.

- Solid Earth and Planetary Sciences
- Petrology and Geochemistry
- Paleontology and Stratigraphy
- Climate, Ocean and Environmental Sciences
- Department Updates
- Field Photo Spotlight
- Travelling to the core: Think!!!
- Cracking Rocks and Laughs
- Upcoming Events / Schedule

SOLID EARTH and PLANETARY SCIENCES

1. Detection of Microearthquakes and Characterization of Shallow Attenuation Using Optical Fiber.

Seismic hazard assessment requires a good understanding of earthquake source physics and how seismic energy scales with magnitudes. This information is encapsulated in source parameters such as the spectral stress drop, which is a measure of the static stress released during earthquakes. However, characterizing small earthquakes is challenging because of potential biases from wave propagation effects. The attenuation, which is often poorly known, is the main source of inconsistency in spectral stress drops for small earthquakes. In this study, Team of Researchers from Lamont-Doherty Earth Observatory, Palisades, NY, USA demonstrate the potential of using a fiber-optic cable deployed in the borehole with Distributed Acoustic Sensing (DAS) to analyze shallow attenuation and microearthquakes in a geothermal reservoir. The downhole DAS provides an unprecedentedly dense seismic network in the subsurface and a closer recording of the small earthquakes. Researchers obtain the first high-resolution attenuation structure from seismic observation. The near-surface high attenuation echoes the importance of accounting for shallow attenuation when modeling the seismograms. The spectral stress drop variation likely characterizes the subsurface heterogeneity or comes from more complex sources. The study shows that downhole DAS can provide new attenuation observations in the

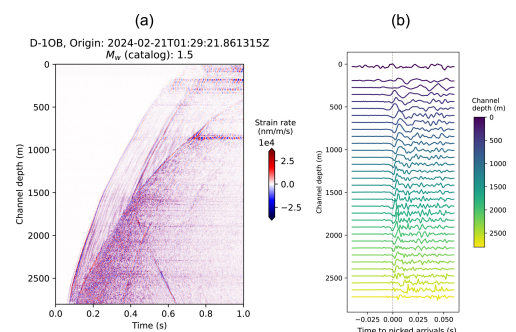


Figure 1: A microearthquake event (Catalog $M_w = 1.5$, Event 1): (a) Wavefield captured by Distributed Acoustic Sensing in the vertical well D-10B. (b) Raw P-wave arrivals (normalized by the maximum amplitude), aligned by the picked time (dashed line) of a kurtosis picker.

crust and improve our ability to model small earthquakes if we carefully account for the instrument response of the cable.

Reference: Chang, H., Nakata, N., Abercrombie, R. E., Dadi, S., & Titov, A. (2026). Characterizing shallow attenuation and microearthquake source parameters using a downhole DAS array at the Cape Modern geothermal field. *Journal of Geophysical Research: Solid Earth*, 131, e2026JB034276. <https://doi.org/10.1029/2026JB034276>

2. Heavy boron isotopes reveal deep carbon recycling in hot subduction zones.

The efficiency of deep carbon recycling in hot subduction systems remains debated, with contrasting models predicting either extensive shallow decarbonation or substantial carbonate retention within the subducted slab. Here, scientists from China present boron-isotope and geochemical data from olivine-hosted melt inclusions in volcanic arc adakites from western Panama and in forearc high-Mg andesites from SW Japan, representing modern and Archean-like hot subduction systems. Olivine-hosted melt inclusions exhibit elevated $\delta^{11}\text{B}$ values (up to +23.2‰) coupled with high Ce/Pb, La/Yb, Eu/Ti, and Th/Zr ratios, indicating melt contributions from subducted carbonate-bearing lithologies. Integration with regional CO_2 flux estimates from western Panama suggests that more than $\sim 60\%$ of slab carbonate escapes shallow decarbonation, likely owing to extensive forearc and arc dehydration causing substantial fluid loss, thereby suppressing fluid-mediated decarbonation beneath both the deeper forearc and arc front. These results demonstrate that substantial carbon can bypass shallow decarbonation in both modern and Archean hot subduction systems.

Reference: Liu, HQ., Tian, F., He, MH. et al. Heavy boron isotopes reveal deep carbon recycling in hot subduction zones. *Nat Commun* (2026). <https://doi.org/10.1038/s41467-026-78096-6>

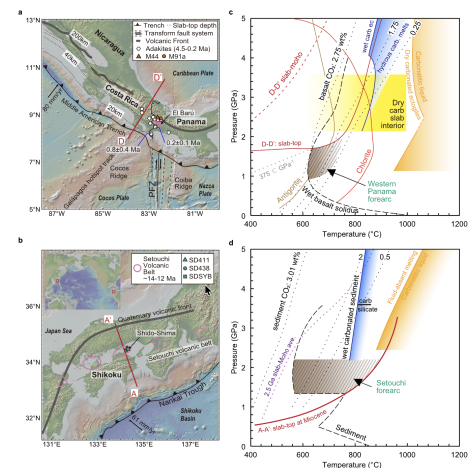


Figure 2: Tectonic framework and slab thermal structure of the southern Central American Volcanic Arc and the Setouchi Volcanic Belt.

Petrology and Geochemistry

3. Crystals Reveal How Magma Recycles Deep Beneath Ocean Islands.

The temporal evolution of the magmatic plumbing system beneath the Cumbre Vieja volcano in La Palma has remained remarkably consistent across the 1712, 1971, and 2021 eruptions. By analyzing the chemical zoning of clinopyroxene crystals using quantitative trace element mapping, electron microprobe analyses, thermobarometry, and cluster analysis, researchers discovered that a relatively cool (1000-1025°C) and highly evolved tephri-phonolitic to phonolitic crystal mush continuously resides in the upper mantle at depths of 18 to 25 kilometers. The highly evolved cores of these crystals indicate that they act as "antecrysts," which crystallized from this ancient, stagnant mush rather than from the more recent carrier melts. At least four to seven days before an eruption, a fresh and hotter (1100-1150°C) basanitic magma rises from deeper within the mantle to infiltrate this evolved mush. This chromium-rich mafic recharge essentially disaggregates, recycles, and "unlocks" the stagnant material, forcing the magma to mobilize upward. However, this deep mixing is likely not the immediate trigger for the eruption itself; instead, the magma may temporarily stall in the shallow crust at depths of 5 to 10 kilometers. The actual onset of the eruption is likely driven by progressive reservoir pressurization caused by subsequent magma differentiation and volatile exsolution, followed by a rapid final ascent to the surface over just one to three days. These magmatic dynamics observed at La Palma have significant global implications, as they are likely representative of low-flux ocean island basalt (OIB) volcanoes worldwide. The researchers suggest that during the initial, peak-flux evolutionary stages of ocean islands—such as the Galápagos or Cape Verde—magma continuously accumulates deep in the upper mantle, maintaining evolved mushes that are periodically evacuated by mafic recharge. As these volcanic systems mature and their magma flux decreases, their primary storage systems tend to migrate to shallower crustal levels. Because significant magma evolution in initial-stage low-flux OIBs occurs at depths often undetected by standard geophysical monitoring, these deep, cryptic magmatic processes pose major challenges for accurate volcanic hazard forecasting.

Reference: Caracciolo, A., Ubide, T., Ágreda-López, M. et al. Recurrent evacuation of mantle mush in ocean islands revealed by clinopyroxene from La Palma. *Nat Commun* 17, 9362 (2026). <https://doi.org/10.1038/s41467-026-77213-9>

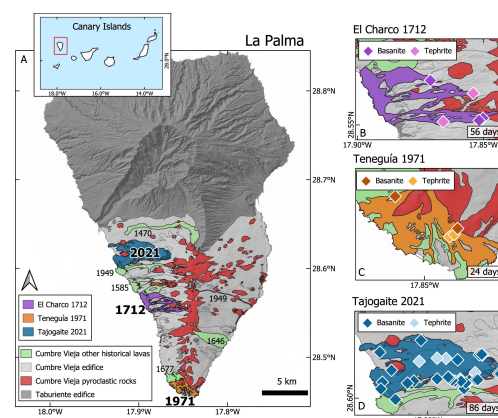


Figure 3: A Simplified geological map of La Palma island, with inset showing the location of the island in the Canaries. The Cumbre Vieja edifice shows historical eruptions that have occurred since the 15th century. B–D Zoom of historical eruptions studied in this work and sample localities of (B) El Charco 1712, (C) Teneguía 1971, and (D) Tajogaite 2021 eruptions. Sample location is indicated by colored diamonds, distinguishing between amphibole-bearing tephrite and olivine-bearing basanite samples. The duration of each eruption is shown in the bottom right corner. Geological data are from the Cartográfica de Canarias.

Paleontology and Stratigraphy

4. Before the Snows: New Study Pushes Animal Origins Back to 800 Million Years Ago

A multi-institutional team of researchers from the University of Oxford and Yale University notes that divergent models persist for the emergence of animals.

Lipid biomarkers suggest animals originated before 635 million years ago (Ma), but their body fossil record extends to only 574 Ma. Molecular clocks might differentiate between these records, but the researchers demonstrate how their accuracy and precision hinge on maximum age calibrations.

The team evaluated the Ediacaran Weng'an Biota (China) as a maximum calibration utilizing microfossils from the Kheseen Biota (Mongolia).

These two biotas have similar preservation and microfossil assemblages, containing no definitive animals. The Kheseen Biota, deposited at a time (~550–526 Ma) when animals were undoubtedly present, questions the validity of the Weng'an calibration.

The researchers discuss the uncertainty in maximum calibration strategies and propose multiple pre-Ediacaran deposits with favorable taphonomy, preserving both non-animal body fossils and biomarkers, as currently the most reliable calibrations. Their analyses support a late Tonian to mid-Cryogenian (~800–700 Ma) origin for Metazoa.

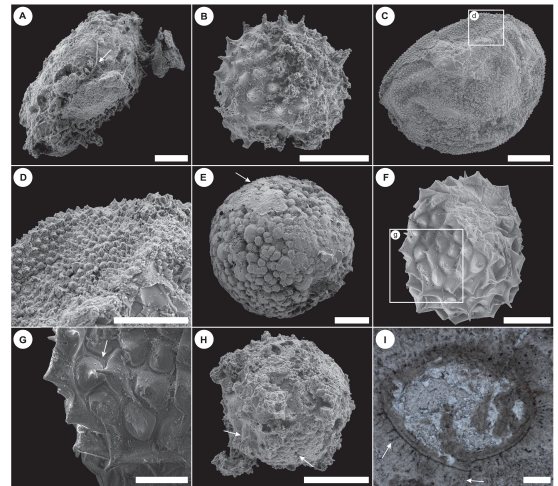


Figure 4: Acanthomorph acritarchs of the Kheseen Biota.

Reference: Orin M. Lole Durbin et al. ,Re-evaluating molecular clock maximum age calibrations revives pre-Ediacaran divergence estimates for animals.Sci. Adv.12,eag6289(2026).DOI:10.1126/sciadv.aeg6289

Climate, Oceans and Environmental Sciences

5. Integrated Assessment of Road Dust in Kolkata, India

Recent study shows how everyday street dust in Kolkata acts as a double threat, polluting both the air people breathe and the local water supply. Street dust is not just ordinary dirt—it accumulates toxic heavy metals such as lead, iron, nickel, and chromium from worn-out vehicle brakes, tires, industrial units, and open landfills such as Dhapa. During the dry, windy pre-monsoon months, dense vehicular traffic resuspends this contaminated dust into the air, where it accounts for 20% of the city's coarse particulate matter (PM₁₀)—surpassing direct exhaust emissions and smoke as a source of coarse particulate pollution. Because this airborne dust is laden with reactive metals, inhalation damages pulmonary cells and elevates the risk of asthma, cardiovascular disease, and other severe health complications.

When the monsoon arrives, the hazard shifts from the atmosphere to the hydrological system as precipitation washes the toxic particulate matter off road surfaces and directly into open drains, as Kolkata lacks a dedicated stormwater treatment infrastructure. While the high discharge of the Ganga River dilutes much of this urban runoff, sluggish channels such as the city's canals and the East Kolkata Wetlands accumulate elevated concentrations of lead, copper, and iron, bioaccumulating in local aquatic fauna and agricultural produce.

To address both environmental challenges simultaneously, the authors argue that regulatory frameworks in India must move beyond monitoring vehicle exhaust and industrial stacks alone to actively regulate and mitigate street dust. They advise that national air quality surveillance systems transition from simply measuring gravimetric mass concentrations to quantifying particle toxicity and reactive oxidative potential. Rather than relying exclusively on capital-intensive vehicle technology and fuel-standard overhauls, the municipal administration can mitigate air and water degradation through practical, cost-effective interventions: regular mechanized street sweeping, paving unpaved road shoulders, and installing roadside vegetative green belts to entrap airborne particulates. Furthermore, introducing decentralized sediment traps and retention basins near major outfalls—particularly in the vicinity of high-load junctions and the Dhapa landfill—would capture heavy-metal-laden urban runoff prior to its discharge into Kolkata's canal network and wetland systems.

Reference: Mazumdar, S., Ghosh, A., Karmakar, J. et al. Urban Road Dust as a Cross-Media Pollutant Reservoir: PM₁₀ Oxidative Potential and Stormwater Metal Contamination in Kolkata. *Water Air Soil Pollut* 237, 1332 (2026). <https://doi.org/10.1007/s11270-026-09989-x>

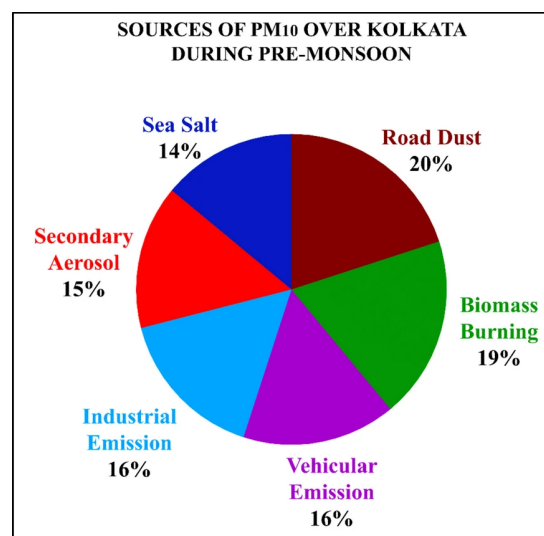
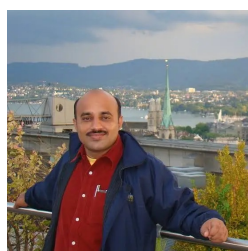


Figure 5: Contribution of different sources to the PM₁₀ aerosols over Kolkata during pre-monsoon season.

Department Updates



Professor Prasanta Sanyal, Department of Earth Sciences, IISER Kolkata has been elected as a Fellow of the Indian Academy of Sciences (IAS).

Field Photo Spotlight



Photographer: Anubhab Das – 22MS

Location: Manali, Himachal Pradesh.

Water sources near the station are being investigated as potential sources of data noise.

Travelling to the core: Think!!!

August 2026 Issue

Question: While surface rocks fracture easily under stress, mountains sustain immense weight for millions of years. Why doesn't a mountain's weight cause the rocks beneath it to fail and the structure to collapse?

Answer: Surface rocks fracture easily under low stress, yet massive mountain ranges sustain their immense weight for millions of years without collapsing. This paradox is resolved by the fundamental shift in rock mechanics at depth.

1. Lithostatic Clamping and the Brittle Regime

At the surface, unconfined rocks fail rapidly along preexisting flaws. With increasing depth z , the lithostatic confining pressure rises rapidly:

$$P = \int_0^z \rho(z')g \, dz' \approx \rho g z$$

For typical crustal rock ($\rho \approx 2700 \text{ kg/m}^3$), P increases by roughly 27 MPa/km. According to Byerlee's law, shear stress τ required for frictional failure scales directly with effective normal stress σ'_n :

$$\tau = \mu(\sigma_n - P_f)$$

where $\mu \approx 0.6\text{--}0.85$ and P_f is pore fluid pressure. The immense confining pressure clamps micro-cracks shut, dramatically raising the differential stress $\Delta\sigma = (\sigma_1 - \sigma_3)$ required to induce shear failure.

2. Ductile Flow and Strength Envelopes

Beyond depths of 10–15 km ($T \gtrsim 300\text{--}400^\circ\text{C}$), deformation transitions from brittle faulting to ductile dislocation creep, governed by thermally activated power-law rheology:

$$\dot{\epsilon} = A (\sigma_1 - \sigma_3)^n \exp\left(-\frac{Q}{RT}\right)$$

Rocks no longer fracture; they relax high differential stress over geological timescales by flowing viscously without losing structural integrity.

3. Isostasy: The Buoyancy Foundation

A mountain is not an unsupported surface pile; it is buoyantly compensated. In the Airy isostasy model, a topographic elevation h is balanced by a deep, low-density crustal root r displacing denser mantle:

$$\rho_c(h + r) = \rho_m r \implies r = h \left(\frac{\rho_c}{\rho_m - \rho_c} \right)$$

For $\rho_c \approx 2700 \text{ kg/m}^3$ and $\rho_m \approx 3300 \text{ kg/m}^3$, $r \approx 4.5 h$. Hydrostatic buoyancy in the upper mantle bears the load rather than the elastic shear strength of the crust. Over extended horizontal wavelengths, lithospheric flexural rigidity $D = \frac{ET_e^3}{12(1-\nu^2)}$ distributes stresses across hundreds of kilometers, preventing localized foundation failure.

Question for the next issue: The Sea Level Paradox:

Imagine: The complete melting of a polar ice sheet—such as Greenland—discharges an immense volume of water into the global ocean, sufficient to drive a global mean Eustatic Sea Level (ESL) rise of approximately 7 meters. Yet, geodetic and tide-gauge models demonstrate that within roughly 1,000 to 2,000 km of the ice margin, the local relative sea level does not rise at all. Instead, it drops dramatically—often by tens of meters. Why does removing a multi-kilometer-thick mass of ice cause coastal water levels near the ice sheet to fall while the global average surges? Hint: Do not view the ocean as a rigid bathtub filling with water, nor the ice sheet as a passive block. Treat the ice sheet as a massive localized gravitational attractor and the solid Earth beneath it as an elastic medium. What happens to the marine geoid (an equipotential surface of gravity) when billions of metric tons of mass vanish, and how does the underlying lithosphere adjust elastically to the sudden release of overburden?

Cracking Rocks and Laughs

1. Why did the fold get arrested? Because it was caught rolling a joint.

2. An engineer, a geologist, and a geophysicist are sitting together when an observer approaches and asks a simple question:

“What is $2 + 2$?”

The **engineer** calculates quickly and states:

4.000 ± 0.001

The **geologist** gestures broadly and replies:

≈ 4 (give or take a few million, pending field verification)

The **geophysicist** closes the door, draws the blinds, leans in, and whispers:

“What do you want it to be?”

3. A physicist, a biologist, and a geologist were asked what they would like their relatives, friends, and colleagues to say at their funeral.

The **physicist** reflects calmly:

“I want my family to say I was deeply loved and will be missed, and my colleagues to mourn the loss of an exceptional mind.”

The **biologist** speaks with ambition:

“I want everyone in tears, declaring that the world has lost the greatest biologist since Darwin.”

The **geologist** ponders deep time for a moment, scratches his chin, and replies:

“Well... I’d just like someone to look into the casket and shout:”

“LOOK, HE’S MOVING!”

Announcement:

The Earth Club is Looking for you!!

1 Design and Creative Team of Earth: The Journal Club

Dear all,

The Earth Club is looking for enthusiastic members to join our team, help us grow, and strengthen our earth science community! We are inviting web developers, graphic designers, and anyone with a passion for creativity to bring their unique skills to the table.

How to Apply: If you are interested in joining our team, please send an email to earth.club@iiserkol.ac.in or fill out the application form linked below. We are excited to hear from you and look forward to welcoming new members to our team!

Link: <https://docs.google.com/forms/d/e/1FAIpQLSf3fd2fnarech0yhj-gUouO5gBvBgucPsd7a5i8nL2K-5LAzA/viewform?usp=dialog>

Want to submit a field photo, contribute to the newsletter, or write a blog post?

Reach out to us. Email us at earth.club@iiserkol.ac.in.

The Plates keep moving. So do we:

Writer: Parshwa Pavankumar Boke

Writer and Editor: Neetesh Singh Narwariya

Thiiiiissssss is the endddddd.....