IESO 2026 TURIN

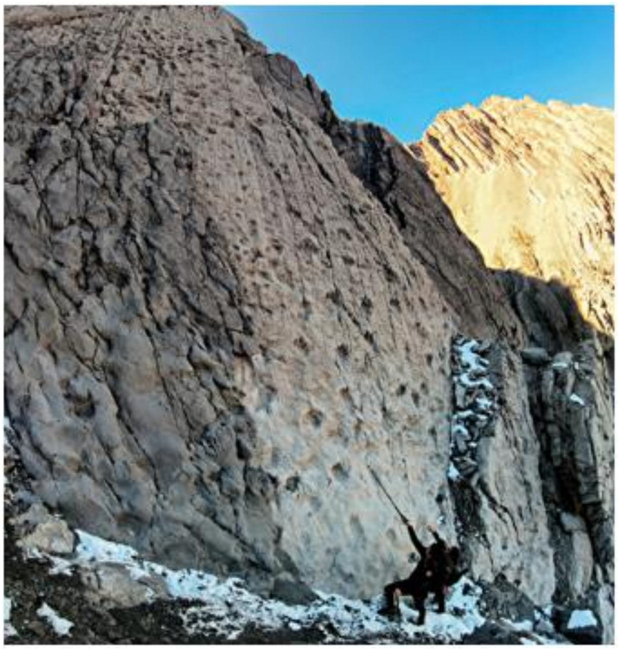
WRITTEN TEST 3 — A FIELD TRIP INTO THE TRIASSIC

Triassic footprints in the Alps: a forgotten carbonate-platform margin

Time: 80 minutes • Questions: 30 • Score: 30 points • Read all the data before answering. Only one correct answer for all questions.

In December 2025, during a survey in the Stelvio National Park (Upper Valtellina, Italy), thousands of fossil footprints were discovered on an almost vertical rock face at about 2,000 m elevation. The tracks, dated to about 210 million years ago (Late Triassic, Norian), represent an exceptional window into this distant past.

The site records the margin of a carbonate platform: the footprints are preserved in dolostones (Dolomia Principale / Livigno Formation), deposited in a shallow epicontinental sea at the margins of the Tethys ocean. The study explores the interconnections between taphonomy (the study of fossilization processes), paleogeography, ichnology (the study of fossil traces), evolution, and mass extinctions.



Fossil tracks of Late Triassic (Credits planetmountain.com)

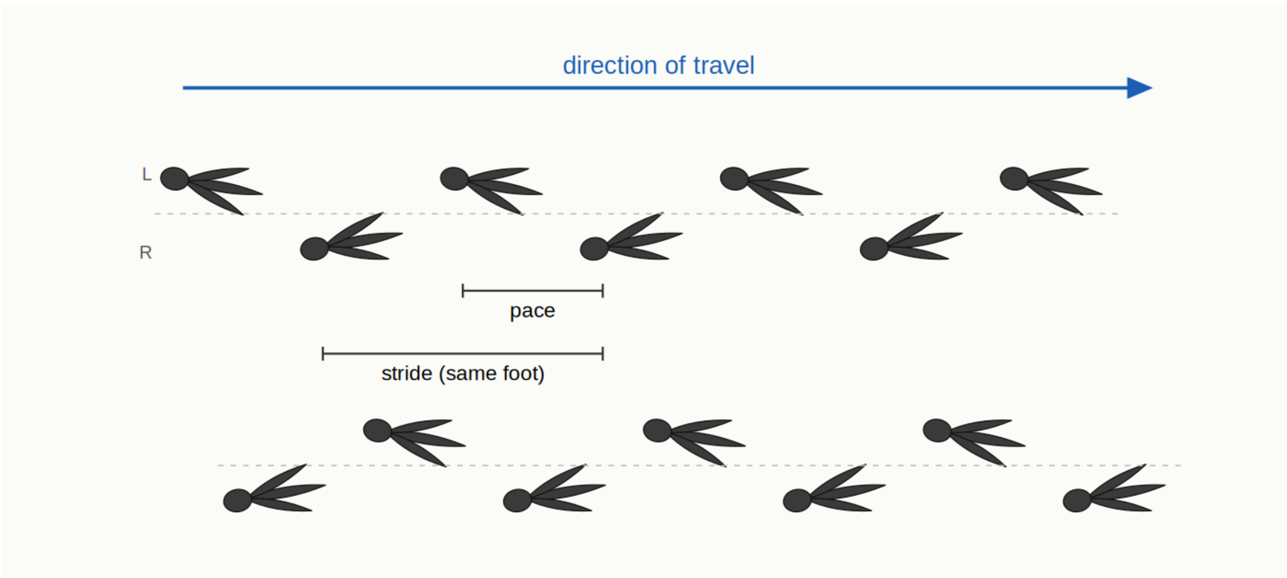


Figure. 1 - Reconstruction of two parallel trackways of Triassic archosaurs (tridactyl footprints). IESO 2026 teaching diagram based on ichnological data from the Fraele site, Val di Stelvio (Stelvio National Park, December 2025; ichnologist F.M. Petti, MUSE Trento).

SECTION A: THE SITE AND TAPHONOMY — Questions 1–9

Question 1
The footprints at Fraele are exceptionally well preserved. Which combination of conditions was most likely?
A. Dry substrate at the time the organism passed, rapid hardening and burial before atmospheric or biological disturbance.
B. Dry substrate at the time the organism passed, sudden water saturation, and rapid burial before atmospheric or biological disturbance.
C. Plastic substrate at the time the organism passed, glacial or snow cover that kept the substrate isolated until hardening.
D. Plastic substrate at the time the organism passed, rapid hardening and burial before atmospheric or biological disturbance.

Question 2
The mud-cracks (polygonal desiccation cracks) associated with the footprints imply that the substrate…
A. was periodically exposed to the air until it dried out, and was then submerged again.
B. remained permanently submerged in deep waters, below wave base.
C. was periodically exposed only briefly before remaining permanently submerged.
D. underwent repeated compaction beneath accumulating sediment without surface exposure.

Question 3
Some ripple marks preserved on the surfaces mainly provide information on…
A. the direction of the prevailing winds responsible for sediment transport across the basin.
B. the absolute age of the deposit through the spacing and amplitude of the ripple crests.
C. seasonal changes in Triassic seawater recorded by the ripple geometry.
D. current direction, depositional energy, and water depth.

Question 4
Which process would have most hindered the preservation of an already-formed footprint before its burial?
A. Rapid burial beneath carbonate mud followed by arid conditions.
B. Early cementation of the sediment.
C. Formation of a microbial mat (biofilm).
D. Bioturbation of the sediment.

Question 5
What is the most likely outcome if a well-formed footprint on wet mud is repeatedly crossed by other animals before burial?
A. The footprint becomes more resistant to erosion because of sediment compaction.
B. The footprint can be obliterated by repeated reworking of the sediment.
C. The footprint becomes more sharply defined because of improved lithification.
D. The general outline of the footprint is preserved, with loss of the fine details.

Question 6
The dolostones that preserve the footprints, associated with mud-cracks and ripple marks, indicate a depositional environment of a…
A. shallow carbonate tidal flat with periodic subaerial exposure.
B. carbonate basin below wave base with continuous marine sedimentation.
C. deltaic coastal plain with abundant siliciclastic sediment input.
D. fluvial environment dominated by river-channel deposition.

Question 7
In the transformation of the sediment into consolidated dolostone that preserved the footprints, which combination of diagenetic processes is most correct?
A. Compaction, dissolution, and recrystallisation of the sediment.
B. Compaction, cementation, and partial melting of carbonate minerals.
C. Compaction, cementation, and crystallisation of carbonate minerals.
D. Compaction, cementation, and bioturbation of the sediment.

Question 8
In the taphonomic sequence, why is burial considered the most critical phase?
A. A dry substrate that is never buried remains visible and easy to find.
B. Coarse burial maintains fossil details during compaction.
C. If burial occurs too late, the footprint might not consolidate.
D. Without burial, tectonic uplift will expose the footprints to erosion.

Question 9
A footprint-bearing layer shows well-developed mud-cracks and, at the same time, very fine, well-preserved anatomical detail, even though mud-crack desiccation tends to destroy fine details. Which interpretation could explain this apparent contradiction?
A. Rapid burial occurred before prolonged surface deterioration.
B. Mud-cracks formed before the footprints were impressed.
C. Cracks helped air circulation and thorough stiffening of details.
D. Water covering after cracking hydrated the anatomical details.

SECTION B: PALAEOGEOGRAPHY AND TECTONIC SETTING — Questions 10–15

Question 10
The Triassic strata of the site, almost vertical today, owe this geometry mainly to the collision between the Adria/Apulia plate and the European plate during the Alpine orogeny (Cretaceous–Cenozoic). This process included…
A. intrusion of batholiths that uplifted and rotated the strata through thermal effects.
B. differential erosion that progressively tilted the more resistant beds.
C. the overthrusting of various sections of the bed of the ocean marshy margin.
D. Jurassic rifting that tilted the blocks along normal faults.

Question 11
The crystalline basement of the area is in greenschist facies (low-grade metamorphism). Which observation excludes a higher level of metamorphism?
A. the presence of almandine garnet and kyanite.
B. the preservation of recognizable fossils.
C. the presence of sillimanite, typical of higher temperatures above ~600 °C.
D. partial melting with widespread leucocratic veins (migmatites).

Question 12
In the Late Triassic, the Tethys Ocean was connected to the Panthalassa through an equatorial seaway. Which consequence has been the most likely?
A. Marine organisms remained largely isolated because equatorial waters formed a major thermal barrier between the two oceans.
B. Because of thermal layering of the waters, only planktonic organisms dispersed between the two oceans, while nektonic and benthic organisms remained isolated.
C. Cold currents from the Panthalassa flowing through the seaway reduced marine biodiversity along the Tethyan margins.
D. Warm equatorial circulation promoted the dispersal of marine organisms and contributed to high tropical biodiversity.

Question 13
Given the palaeolatitude of the site (~10–20°N), atmospheric CO_2 concentrations 3–4 times higher than today, and the absence of polar ice caps, the most likely climate at the site was:
A. Temperate with cool winters and seasonal snowfall.
B. Persistently arid, with minimal rainfall throughout the year.
C. Equatorially warm and humid throughout the year, with little seasonal variation.
D. Warm with pronounced wet and dry seasons typical of tropical areas.

Question 14
The strata were involved in the Alpine orogeny (folding and thrusting), yet they preserve footprints and recognizable sedimentary structures. What can be concluded?

A. Deformation occurred at a low grade.
B. The rocks experienced igneous alteration.
C. The footprints formed at a late stage of the Alpine orogeny, with less deformation
D. High-grade metamorphism occurred rapidly and did not erase the footprints.

Question 15
Why do carbonate-platform environments with tidal flats, such as the one described, favour the preservation of tracks?

A. High-energy ocean currents rapidly buried and preserved the footprints.
B. Limited sediment input from still emerging orogenetic areas prevented changes to the footprint after burial.
C. Emergence and exposure stabilized the sediment surface before rapid submergence and burial.
D. Low biological activity prevented modification of the sediment surface during subsidence.

SECTION C: ICHNOLOGY AND BEHAVIOUR — Questions 16–19

Question 16
Compared with fossils of body parts (body fossils), the MAIN added value of these trace fossils (ichnofossils) is that…

A. they provide added taxonomic information than body fossils.
B. they allow an increased anatomy reconstruction of the organism.
C. they can record additional data on behaviour and ecology of the organism.
D. they preserve biological information unavailable with body fossils.

Question 17
From the pace, stride and depth of the footprints, which information is deducible?

A. The approximate size, posture and gait of the organism.
B. The height of the organism deduced by the depth of the footprint.
C. The hunting habits, inferred from the shape of the imprinted toes and claws.
D. The reproductive behavior, deducible by the position of similar prints.

Question 18
On the same bedding plane, parallel trackways of several individuals of the same species, with similar foot and stride (see Fig.1) suggest above all…

A. the higher probability of maintenance of parallel tracks.
B. a substrate that imposes a fixed pattern of movement.
C. the sharing of different individuals of the same habitat.
D. a possible social behavior such as gregarious movements.

Question 19
On the same bedding plane there are footprints of similar shape but very different size. In the absence of other evidence, the most probable interpretation is…

A. extreme sexual dimorphism between males and females.
B. juveniles and adults of the same species.
C. entirely different species with footprints convergent for the same substrate.
D. seasonal variation in the size of the same individual.

SECTION D: EVOLUTIONARY ADAPTATIONS AND ECOLOGY — Questions 20–23

After the great Permian-Triassic extinction (252 Ma), terrestrial fauna was dominated by archosaurs and basal reptiles; primitive mammals, small and nocturnal, were present but ecologically marginal. The Late Triassic tidal-flat environment included periodic flooding, subaerial exposure, soft carbonate mud, and seasonal environmental variability.

Question 20

Compared with the sprawling posture, some Triassic archosaurs evolved an erect posture (limbs beneath the body): which major advantage would this locomotor adaptation provide?

A. The acquisition of endothermy, with independence from soil temperature.
B. A lower energy cost in prolonged terrestrial locomotion.
C. A greater body surface exposed to the atmosphere for thermoregulation.
D. A greater possibility to breathe air during flooding periods.

Question 21

In a carbonate-platform environment with tidal flats, the most successful organisms were most likely adapted to…

A. constant marine salinity and permanently submerged conditions.
B. move and seek stable conditions during stress.
C. fluctuations in salinity, temperature, and periodic exposure.
D. rapid migration to deeper water whenever conditions changed.

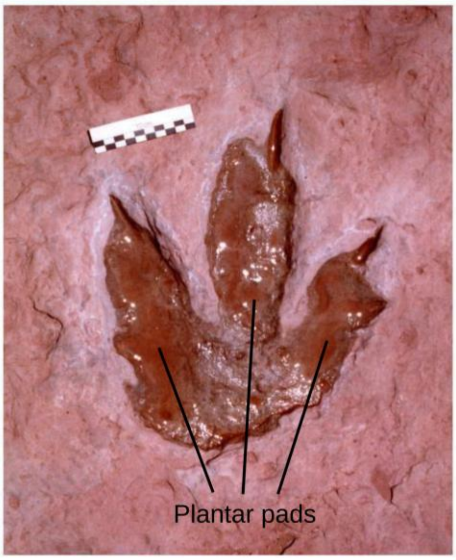


Figure 2: Theropod footprint (courtesy of Marco Avanzini, Museo Tridentino di Scienze Naturali – Trento)

Question 22

Footprints evidenced well-developed plantar pads (see Fig. 2), which represent an adaptation mainly to…

A. locomotion on soft, muddy substrates, distributing the weight over a larger surface.
B. gripping prey on the ground, improving stability during the attack.
C. thermoregulation, absorbing the heat of the ground in an arid environment.
D. locomotion on hard rock, increasing friction and preventing slipping.

Question 23

Geochemical models (See Fig. 3) indicate for the Late Triassic a reduction of atmospheric O_2 level. The most plausible ecological consequence for terrestrial fauna is…

A. the survival of anaerobic organisms, with the exclusion of terrestrial vertebrate with intense aerobic respiration.
B. a progressive adaptation of the aerobic metabolism of many organisms.
C. a subsequent gigantism in all terrestrial vertebrates, because of a presumed greater respiratory interface which is favoured at low oxygen.
D. an increase in terrestrial fauna development, since breathing atmospheric O_2 became easier.

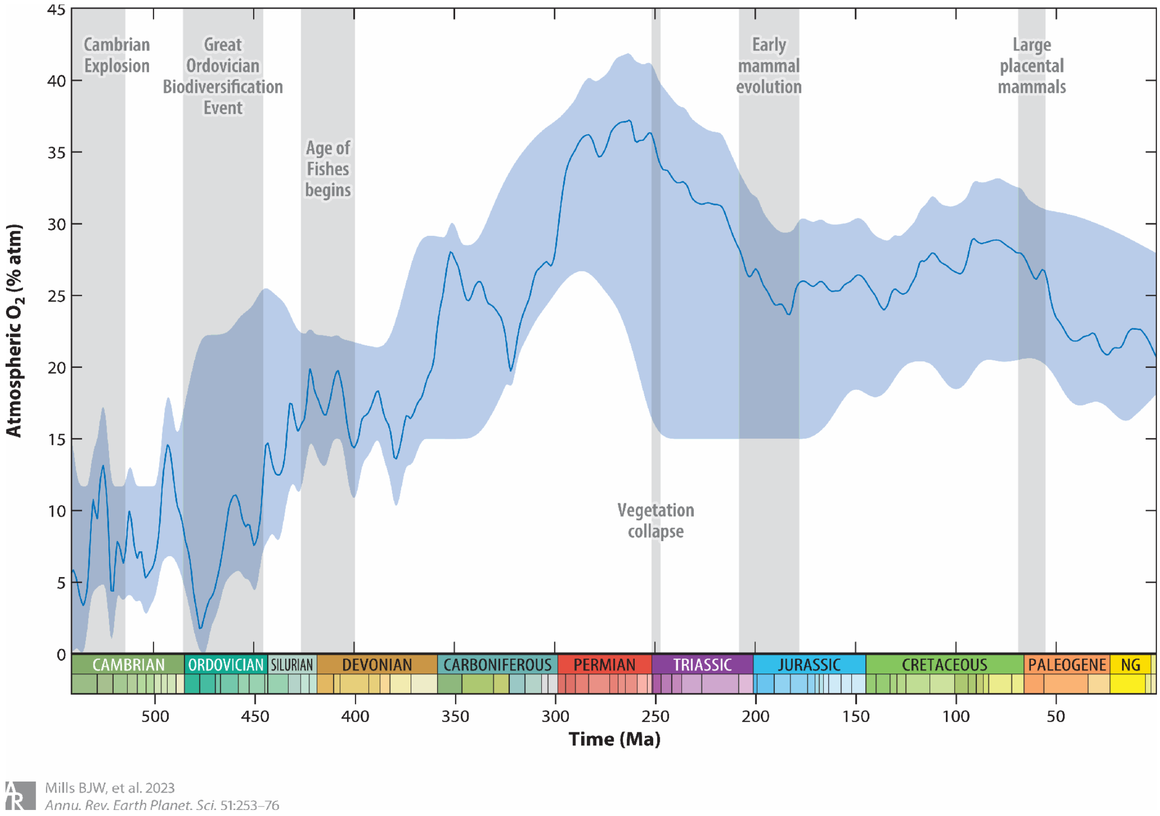


Figure 3. Phanerozoic O_2 curve (blue line). The shaded area incorporates different Phanerozoic O_2 estimations. The O_2 variations are compared to key biological events (Annual Review of Earth and Planetary Sciences - Open Access)

SECTION E: MASS EXTINCTIONS AND THE EARTH SYSTEM — Questions 24–30

Table 1 – The five great extinctions of the Phanerozoic.

Event	Age (Ma)	% species lost	Main cause / stress
End-Ordovician	444	~85%	glaciation and regression (cooling)
Late Devonian	372	~75%	oceanic anoxia, LIP
End-Permian (P-T)	252	~96%	Siberian Traps (LIP), super-greenhouse effect
End-Triassic (T-J)	201	~76%	CAMP (LIP), ocean acidification
End-Cretaceous (K-Pg)	66	~76%	Chicxulub impact + Deccan Traps, impact winter

LIP = Large Igneous Province; CAMP = Central Atlantic Magmatic Province

Question 24

The Stelvio footprints lie stratigraphically below the levels associated with the T-J extinction. What can be correctly deduced about the organisms that left them?

A. They lived before the T-J; stratigraphy does not indicate whether their descendants survived it.
B. They survived the T-J and are direct ancestors of Jurassic dinosaurs.
C. The T-J event did not affect Alpine coastal ecosystems, which were already above water level.
D. Those organisms became extinct at the T-J boundary.

Table 2 – Late Cretaceous to Early Paleogene (K-Pg) boundary interval

Ma (Million Years Ago)	Event
~66.50	Onset of Deccan Traps
~66.40–66.10	Pre-Impact Hyperthermal Outgassing
~66.05	The Chicxulub Asteroid Impact & Main Extinction Pulse
~66.05-66.00	Impact-Accelerated Deccan Volcanism
~65.50	Deccan Volcanism Subsides / Early Paleogene Recovery

Question 25
The end-Permian extinction is linked to the Siberian Traps and a super-greenhouse climate. Why was it more devastating than other extinction events?

A. Rapid cooling dropped the temperature in tropical ecosystems.
B. Over-heating of the oceans caused repeated tsunamis that destroyed most coastal ecosystems.
C. Volcanic ash blocked sunlight for decades.
D. Prolonged warming disrupted both marine and terrestrial ecosystems.

Question 26
On the relationship between the Chicxulub impact and the Deccan Traps, which statement best reflects the current state of research on this mass extinction event?

A. The Deccan began to erupt about 50,000 years after the impact, activated by its seismic shocks propagated through the mantle, causing the primary extinction incidence.
B. The Deccan contributed to the gradual global warming thousands of years earlier than the impact, which then triggered a subsequent ecosystem destabilization that finalized the extinction.
C. The climatic effect of the Deccan eruptions was negligible compared with the direct effects of the Asteroid impact.
D. Eruption phases of Deccan Traps and the Asteroid impact overlapped, but happened entirely independently, with no direct relationship between volcanism and asteroidal effects.

Question 27
After the K-Pg, mammals diversified rapidly from the few surviving groups, occupying the multiple ecological niches freed by the non-avian dinosaurs and other extinct species. This process is an example of…

A. convergent evolution: different taxa independently develop similar forms adapting to the same environments.
B. stabilizing selection: selective pressure conserves the mean characters already present in the population.
C. adaptive radiation: rapid diversification of few taxa into many forms adapted to different ecological niches.
D. cascade extinction: the loss of one taxa drags down the progressive collapse of the other groups that depend on it.

Question 28
The T–J extinction is linked to CAMP volcanism followed by ocean acidification. How can this be explained?

A. Water vapour released during submarine eruptions diluted seawater and lowered its pH.
B. Melting of icecaps cooled the oceans, increasing solubility of acidic gases.
C. Carbon dioxide produced by volcanic eruptions dissolved and acidified seawater.
D. Increased evaporation concentrated dissolved salts, lowering seawater pH.

Question 29
The archosaurs footprints (~210 Ma) date before the Triassic–Jurassic (T-J) extinction. Which event most likely explains the dominance of archosaurs at the site?

A. The P-T extinction had freed the niches later occupied by the archosaurs.
B. The archosaurs themselves were involved as being partially responsible of the T-J extinction.
C. The T-J extinction was already in action, favoring the archosaurs.
D. The composition of the fauna was not related to mass extinction events, which were far in time.

Question 30
The same extinction event might be geologically recorded by opposite climatic signatures in the sediments: warming or cooling. Both mechanisms derive from emissions of greenhouse gases such as CO_2 and CH_4, and dust and aerosols. Which explanation best accounts for this apparent contradictory effect?

A. The climatic response depends mainly on the latitude of the affected region, because local temperature acts differently on the emissions.
B. Different atmospheric emissions are necessarily caused by different geological events which happen simultaneously.
C. Emissions generally cause global cooling, but the heat produced by volcanic lava can generate local warming.
D. Greenhouse gases warm over long timescales, while dust and aerosols block the solar radiation causing rapid, brief cooling.