– An international journal for New Concepts in Global Tectonics –

NCGT JOURNAL

Editor-in-Chief: Bruce LEYBOURNE (leybourneb@iascc.org)

NCGT Journal
New Concepts in Global Tectonics

Volume 14, Number 3
March 2026

ISSN 2202-0039

WWW.ncgtjournal.com

Image of "Sun bird" captured by the LASCO C2 chronograph aboard SOHO, (February 2, 2026).

See Fig. 18 Hawthorne, Robert Jr. this issue

The appearance of the Golden Kite (kinki) represents the visual peak of the solar outburst

1st Quarterly Issue

NCGT Journal
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Volume 14, Number 3, March 2026

ISSN number; ISSN 2202-0039

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NCGT Journal
New Concepts in Global Tectonics

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Volume 14, Number 3,March 2026

ISSN number; ISSN 2202-0039

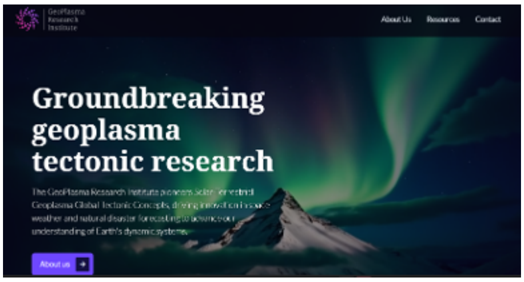
EDITOR's CORNER: - by Editor in Chief - Bruce Leybourne

Geoplasma Research Presents

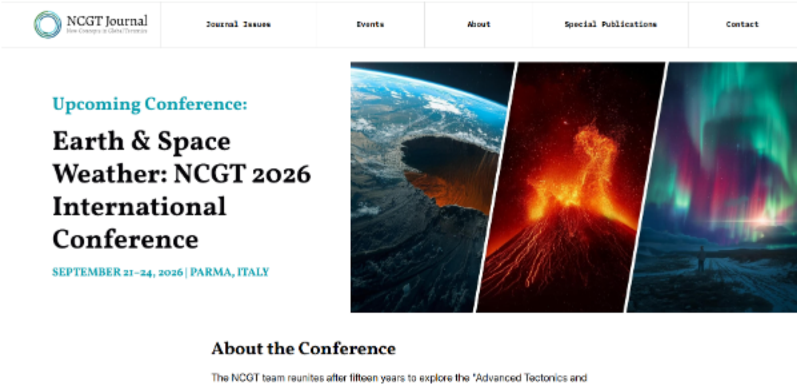
NCGT 2026 CONFERENCE

Parma Italy

a NCGT Journal Production



Earth and Space Weather
Advanced Tectonics - Earthquake Forecasting



Fifteen years have brought significant advancements in our technology - driven science, since our conference in India (2011) "Earth Dynamics - Perceptions and Deadlock ". We highlighted unresolved issues within prevailing tectonic theories despite decades of accumulating data.

Offering new perspectives on our cosmos and, consequently , our planet . This conference provides a vital platform for scientists to present, listen , and engage in discussions about the history and ultimate destiny of our Pale Blue Dot . Join us to explore the evolving understanding of Earth 's dynamics.

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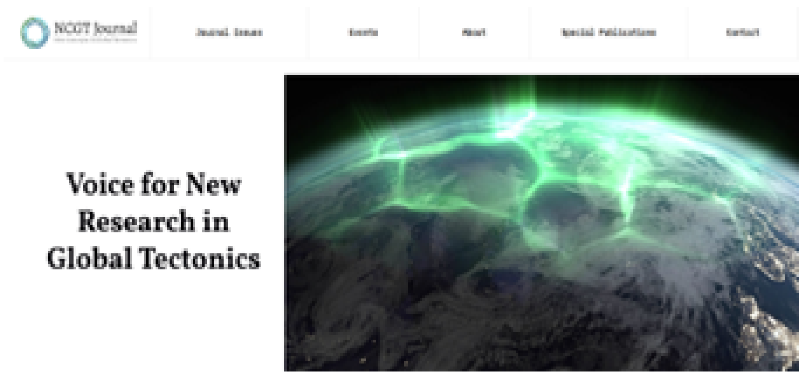

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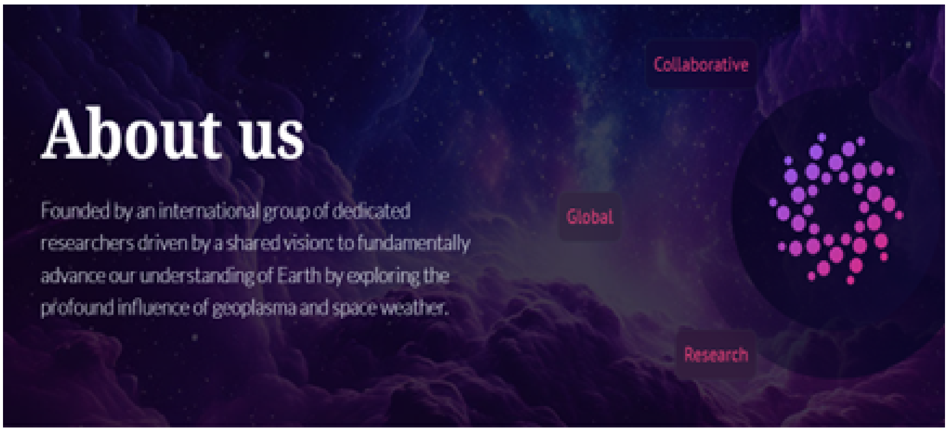

Conference details: 21-24 September 2026 – NCGT in Parma, Italy
Organized by Valentino Straser (valentino .straser @gmail . com)
Information website about the city of Parma and its province: https://parmawelcome.it/

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Single room , two coffee breaks /lunch /dinner €185 .00 plus a €4 tourist tax . See : https :// www . hotelparmaecongressi.com/

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Timetable for participating in the conference:
Open abstract March 15, 2026
Abstract acceptance May 31
Payment (TBD) due by June 15, 2026 (To organizing committee)
Publication of conference and abstract book September 1, 2026

Regarding information for authors:
Abstract: 150 words (maximum)
Short CV: 300 words (maximum) and a photo.
For formatting and fonts, use NCGT Journal.
Abstract submission opens March 15, 2026
Conclusion: May 31, 2026
Confirmation of abstract acceptance: June 15, 2026

"Earth and Space Weather Advanced Tectonics and Earthquake Forecasting between Heaven and Earth " summarizes the contents of the NCGT 2026 Conference scheduled in Parma from September 21 to 24 , 2026 . The NCGT team reunites after fifteen years , to discuss Earth model innovations and scenarios for understanding geophysical processes and space weather effects . More traditionally , new models of Global Tectonics and explored understanding Earth by looking beyond traditional boundaries of geology and geophysics, combining expertise ranging from electromagnetism to atmospheric physics to space weather.

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ISSN number; ISSN 2202-0039

The "Earth & Space Weather " conference objective proposes an integrated interpretation of geophysical phenomena , exploring the role of electromagnetic signals as potential precursor indicators of seismic events and analyzing the contribution of new technologies for data observation and interpretation.

Recent studies inspired by the **global electric circuit** model, a concept developed from the insights of scientists in recent decades , highlight how the Earth 's atmosphere , ionosphere , and planetary surface constitute an electrically connected system. From this perspective, processes occurring in the lithosphere , including those preceding an earthquake , could produce measurable variations in electromagnetic fields and ionospheric properties.

The conference aims to further analyze the so-called "**candidate seismic precursors**" of electromagnetic nature , evaluating their potential and limitations considering the latest scientific evidence. The integration of highly sensitive ground -based sensors , satellite networks, and ionospheric monitoring systems open new perspectives in multi-parametric data collection and modeling of phenomena.

Special focus will be on the role of the Sun. **Solar activity monitoring** from NASA missions and international space weather programs indicate influences in the ionosphere and Earth's magnetic field, have potential implications for climate and geodynamic systems. Understanding the interactions between the solar wind, the magnetosphere, and Earth's internal processes represents a crucial frontier for interpreting complex geophysical events from a systemic perspective.

"Earth & Space Weather " conference therefore proposes new interpretative concepts, encouraging us to move beyond compartmentalized visions to embrace a dynamic and interconnected model of the planet. Earth's evolution is not merely the result of endogenous forces but can be interpreted as the product of a continuous dialogue between space and the surface, between solar energy and deep-seated processes.

Thus the **"Earth & Space Weather "** conference is aimed at researchers , professionals, administrators, and citizens interested in understanding how new technologies and interdisciplinary models can contribute to a more advanced understanding of natural phenomena. It will provide an opportunity for scientific and cultural exchange to explore the future challenges of prevention, sustainability, and risk management on an increasingly complex planet.

Cover Image : **Image of "Sun bird"** captured by the LASCO C2 chronograph aboard SOHO, (February 2, 2026). The appearance of the Golden Kite (kinki) represents the visual peak of the solar outburst. See Fig. 18 - Hawthorne, Robert Jr.. this issue

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New Book

G. P. Gregori (born 1938), Degree in Physics (1961, Univ. of Milan),

B. G. Gregori (born 1967), Degree in Medicine and Surgery (1992) and Specialization in Neurology (1999)

Science is suffering an identity crisis. Our "widespread scientific knowledge" is "static".

Our mind dislikes uncertainty. Not relying on the mainstream is uncomfortable, but we gain better awareness of the world and of ourselves. This book is challenging. It stimulates the reader also on a psychological level, and tries to explain concepts that to most people consider abstruse. It is a journey where mind can dance between quantum physics, cosmology, theology, Greek philosophy and the mystery of life and death. Science is logic, and a scientist can never give up. Many present unsolved paradoxes can find a solution.

At present, we are biased by: 3 "original sins" in Newton's principles, by an Einstein's mistake, and by a misconception of "absolute" time and of the perception of time passing. A new formulation is presented, which is a substantial advancement compared to Galileo, Newton, Maxwell and Einstein.

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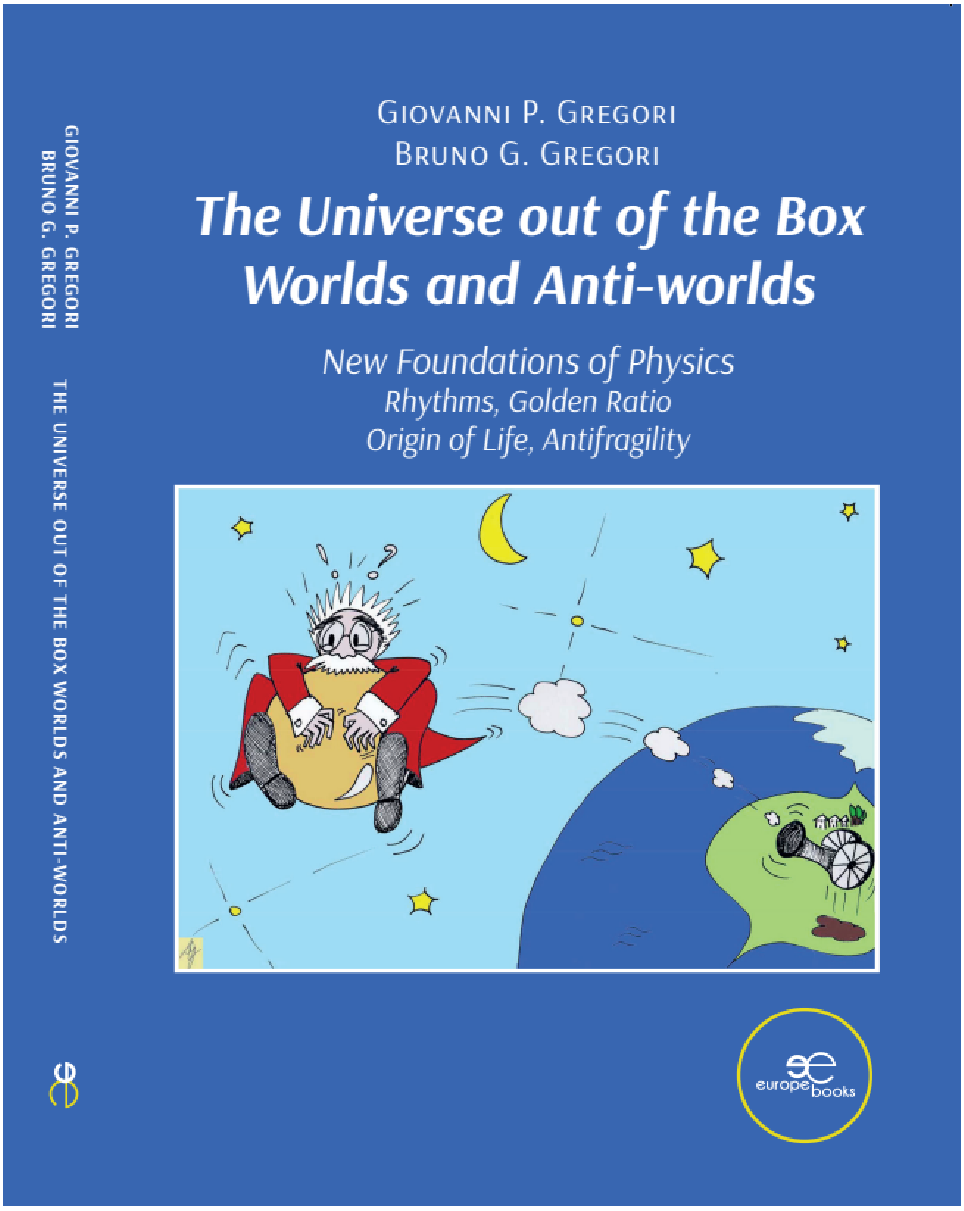

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Company Profiles:

Tesla 3D, Inc. is an independent research and development company with a strong applied science foundation, enabling rapid and practical innovation in the energy and exploration sectors. While not a large enterprise, Tesla 3D, Inc. stays well informed about breakthroughs in electrical generation, storage, and mining technologies. When called upon, the company can comprehend complex challenges and develop strategic, real-world plans that effectively navigate regulations, funding mechanisms, and policies. Tesla 3D, Inc. actively contributes to national and industry advancement through volunteer leadership, including participation in the Homeland Security Taskforce focused on energy resilience and EMP (electromagnetic pulse) threats. The company also set a precedent by independently qualifying for federal Innovation (R&D) Tax Credits; demonstrating that small, agile innovators can leverage these incentives to streamline regulatory solutions and tackle critical infrastructure challenges. This involvement underscores Tesla 3D, Inc.'s commitment to advancing energy security and shaping the transformative role of technology in resource development. Founded: 2011 Colorado by R. Miller.

Geo-Transect LLP (www.tgeo.co.in) Geo-Transect LLP is a knowledge-driven geoscience consultancy, specializing in subsurface exploration and environmental intelligence across India. With core expertise in subsurface mapping, groundwater zonation, aquifer recharge quantification, coastal and shoreline analysis, landscape and topological planning, and island conservation, the firm delivers data-driven insights that empower sustainable planning and development. Representing the forefront of India's earth-science services sector, Geo-Transect blends scientific precision with advanced technologies to support governmental, industrial, and research-based initiatives across southern India and beyond. Integrating indigenous knowledge with global best practices, the firm is committed to environmental stewardship and responsible resource management. Guided by the ethos "With Wisdom in Nature," Geo-Transect envisions a future where scientific understanding harmonizes development with the natural world.

Stellar Transformer Technologies (https://stellartransformertechnologies.com/) is a private geophysical modeling company specializing in modeling the dynamic electro-magnetic Stellar Transformer interactions between Earth-Sun and planets within our solar system. Original research started in 1995 by the current owner and founder during investigations of the seafloor as a geophysicist with the Naval Oceanographic Office at Stennis Space Center. Leading to an understanding and application of new tectonic theories. Later research confirmed dynamic links to space weather affecting a myriad of environmental factors: such as everyday weather; hurricanes; tornadoes; sever weather outbreaks; earthquakes; global climate-change; and certain types of wildfire outbreaks from passing coronal mass ejections induced by internal core generated Electro-Magnetic Pulses (EMP). Current and planned services include mapping of Stellar Transformer circuits; innovative modeling of deep earth magnetics, forecasting Earth's natural hazards listed above; database development and more. Combining big data and AI to find inter-relationships. Developing algorithm inputs for forecasting, data visualization and simulations. All leading to new forecasting technologies. We are actively assisting the EMP Task Force power grid protection efforts with direct input and evaluation of EMP threats. Our company comprehends the complex challenges of geophysical modeling and development of real-world forecasting applications. Electro-magnetic or magnetic induction is the production of an electromotive force, or voltage, across an electrical conductor in a changing magnetic field. The Stellar Transformer Concept contends that simple step-down energy induction occurs between Sun and Earth, much like the transformer process that steps down your household energy from higher voltage transmission lines sourced from the power company. The Sun represents a large coil from the power company, while the Earth represents the smaller coil to your home. The larger coil element generally excites current into the smaller coil element by induction of "step down energy", although lesser feedback mechanisms occur due to the action/reaction principles. Layers within the Earth hold and release charge acting as condensers, or capacitance layers. Thus, the Earth operates somewhat like a battery where energy is either stored or released through time-change of state-of-matter. We combine new Geophysical Intelligence with AI for a winning combination of innovations that will bring new mitigation strategies for space weather to the forefront. Bringing a paradigm shift to the business community for global environmental forecasting based on solar and planetary effects. This will save lives and mitigate property damage using new science and innovative technologies. Many of these ideas were first presented at EU2015 - Electric Universe (https://www.youtube.com/watch?v=IoqgZhbxhhU). Followed up at EU2016 with discussions on geometrical modeling applications, adhering to golden ratio principles (https://www.youtube.com/watch?v=Q355Haapq-0). Founded: 2023 in Colorado by Bruce Leybourne – Owner/Operator.

NCGT Journal
New Concepts in Global Tectonics

New Concepts in Global Tectonics Journal
Volume 14, Number 3, March 2026

ISSN number; ISSN 2202-0039

Seismic Electromagnetic Multi-Variable Meter

John R. Wright[1], Bruce A. Leybourne[2]

In memory of Asa Frings, John's grandson - May Ethan Frings, Asa's brother, who survived mortal combat, be blessed.

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[2] *StellarTransformerTechnologies.com,* Aurora, CO, USA

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Abstract: This paper describes a multivariable instrument that uses 2D Fourier transform technology to process signals from the power grid and an unshielded seismometer to create an overlay of seismic, electromagnetic and electric field information (2, 3). Its power grid 'antenna' is a source of strong Schumann and Alfven wave signals, and a possible cooperative phenomenon involving corona discharge interactions may have been detected. Schumann resonances were detected near the third harmonic (~20 Hz), and the 1 Hz spacing of Alfven plasma wave harmonics were fully resolved. The instrument has shown clearly that seismic phenomena include strong electric effects, along with the established mechanical effects. It is potentially a general tool for seismology and may even illuminate the debate concerning the feasibility of short-term earthquake prediction (perhaps in the 5-minute range) using electromagnetic, pre-quake signals. "The Schumann and Alfven EM signals are **intimately associated** with at least some seismic events because there is a pattern. A positive electric field, a several minutes wavelet, begins the process; the EM signals originate at the peak of the wavelet or on its downslope, and they often continue **beyond the beginning of the quake**. But other quakes, possibly the deeper ones, simply do not produce EM signals."

Keywords: seismic, electro-magnetic, meter, power grid, Schumann, Alfven, plasma, waves, harmonics

Introduction

The 2D multivariable instrument described here (1-3), brings together three sensors: a seismometer, an electrometer and an instrument for detecting the ultralow frequency electromagnetic signals of Schumann resonances and Alfven waves. It has been tested for several years. Seismometers without electrostatic shielding do detect E-fields, but they are generally regarded as useless because the various signals can overlap. However, significant earthquake activity does not happen every day, and the combined electrostatic and seismic baseline is along the time domain, which can separate signals or reveal coincidence. Also, there are occasional + charged wavelet signals lasting around 10 minutes that are also on the seismic baseline. It may be significant that the Schumann and Alfven signals seem to begin at or soon after the time of the peak of a wavelet. These findings apparently agree with those of Freund (4) and the MIT group cited in the supplemental information.

The receiving antenna is the US power grid, and the Schumann and Alfven signals (and others) are in the frequency domain, showing up as heterodynes with the 60 Hz harmonics (all of them!). The 60 Hz harmonics from the power grid are also in the frequency domain, and there is a provision for tuning the 60 Hz harmonics and electromagnetic signals relative to the seismic baseline to avoid a conflict and arrange them appropriately with a specific 60 Hz harmonic. It is a kind of spectrometer for ultralow electromagnetic signals, not just Schumann and Alfven.

The **Results** part of this paper reports on encountered phenomena and useful separations and comparisons of variables. It suggests possible ways to detect oncoming earthquakes, and that was why I built the instrument. For example, Schumann outbursts lead to a quake increase in amplitude and outburst rate significantly during the final five minutes before the quake. The usable amplitudes of slow wavelets, which turned out to be positive electric fields, might also be an especially significant quake indicator. Finally, there may be applications unrelated to the prequake warning issue.

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Experimental

The multi-variable seismometer was not especially hard to build. The seismic motion sensor is a Lehmann mass balance operating near 1 Hz that moves a partially eclipsed knife edge in the beam between an LED and a photo-resistor. The signals generated in the photo-resistor and from the power grid (literally from a domestic wall socket!) merge to pin 9 of a CD4046BE integrated circuit (CMOS), configured as an FM modulator . The antenna signal, which includes Schumann resonances and Alfven waves (and others), passes through a hand -made , high voltage capacitor. The signal from the modulator then goes to the sound card of a computer running SPECTRAN II software. The seismometer is in an enclosure to minimize air currents and darken its interior as much as possible, and it makes hard contact with a concrete slab floor. Sensitivity to electric fields is based on omitting the usual Faraday shielding , which is condemned by most seismologists because seismometers are sensitive to electric fields without shielding. But 2D Fourier transform spectroscopy and other properties separates variables. The instrument is not only a seismometer but also a time-ordered Schumann/ Alfven spectrometer with E-field sensitivity . It is that simple. Instrument details are in references 1 and 2.

Results

The antenna's corona discharge effects

The total power losses, PL, from the power grid, is the sum of three kinds, where the first term, Pac is about 5-7% of the total loss, from resistive heating in the AC wires and transformers. Pc1 is the normal power dissipation due to corona discharge, less than a 1% loss, and Pc2 is an elevated corona discharge because of rain, snow or strong electric fields (as in thunderstorms or the positively charged slow wavelets), and it can cause a 3% power loss (or even higher) from the grid.

$$PL = Pac + Pc1 + Pc2$$

An interesting effect, visible in the left-hand part of **Fig. 1** and beneath a slow wavelet, is a smoothing out of the ripples along the 36th power grid harmonic, 2160 Hz. Such ripples are almost invisible in the first power grid harmonic (60 Hz), and they originate from hunting in the grid's frequency control system. But at the 36th harmonic (2160 Hz) the actual hunting amplitude has been multiplied by 36 and is the waviness you see along the 60 Hz harmonic signals. It is not useless because it identifies signals originating in the power grid.

The smoothing effect does not mean that the control system isn't working, but that the increased corona from Pc2, an ionized gas with metallic-like properties (5), is extending conductivity, thus bypassing the transformers and averaging the 'hunting' of the grid (6).

We may be seeing a cooperative effect in this example, where the parts (transformers and wiring, etc.) are less than the whole (including a corona discharge conductive network spanning the entire power grid), which becomes the "metal-like" surface of a huge antenna. Realistically, the size will not exceed the Pc2 affected region . Note that the signal also fades as the electric field increases (going backward in time, which increases left to right). AI was at first adamant that "noise in the power grid would work against a power grid antenna ." Later the response changed to: "Yes, the power grid can be used as an antenna, either to transmit signals along power lines or as a massive antenna for receiving signals . **Fig. 1** implies that when Pc2 is negligible and Pc1 is dominant, we are using only a local part of the antenna.

[1] From AI - "Hunting" in a control system is an undesirable, continuous oscillation around a setpoint, caused by the system overcorrecting itself in one direction and then overcorrecting in the opposite direction.

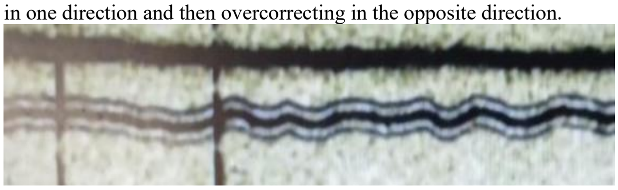

Fig. 1 The dark top line is the seismic baseline; the lower is the power grid 36th harmonic.

The electrometer

This is what happened during an August 5, 2016, thunderstorm. Summer lightning strikes carry negative charges, so the downward discontinuities show that downward is a negative field, thus consistent with positive wavelets being upward deflections of the seismic baseline.

In **Fig. 2**, notice that the 2220 Hz power grid harmonic, the 37th, is smoothed. The electrometer function doesn't require doing anything to the seismometer. Also notice that the seismometer baseline coming from the left margin suddenly dims when the thunderstorm's electric fiend is encountered. It is like a phase transition.

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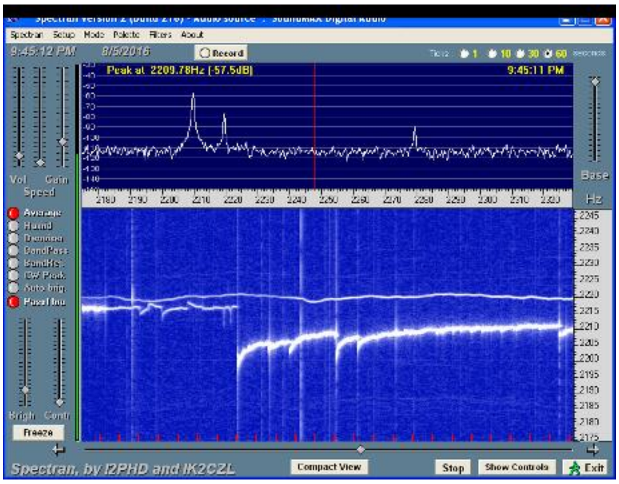

Fig. 2 An August thunderstorm. The power grid's 2220 Hz harmonic is smoothed.

Confirmation: Instrument detects Schumann resonances

It turned out that the instrument detected strong signals at the third Schumann harmonic, which is close to 20 Hz. The antenna is continent sized and possibly resonant with 20 Hz. In Fig. 3 the middle line of the three that are close together is the 36th power grid harmonic (2160 Hz), and the two sequences of Schumann outbursts in the two rectangles are heterodynes of the 20 Hz Schuman signal (count up and down from 2160 Hz using the right-hand scale to verify it). The darkest line, beneath the question mark is the seismometer baseline.

In **Fig. 3**, notice that the amplitude is increasing (time is horizontal, going left to right). Also, the rate of outbursts is increasing, too. That is an ominous pattern. Could it yield five minutes of warning? The increase in the amplitude may be due to strong heating.

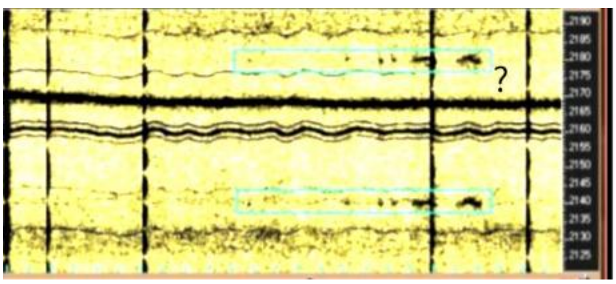

Fig. 3 The quake was mag. 5.5, in West Java, Indonesia, March 1, 2020, at 11:18:39 UTC, which matches the instrument's time for the Schumann teardrop to the upper left of the question mark. AI disputes it, but it's there! The two rows are + and - heterodynes.

Confirmation that the instrument detects Alfven waves

Alfven waves also show up as heterodynes with the power grid harmonics, but they come in families of 1 Hz harmonics. **Fig. 4** is a typical recording, and the 1 Hz spacing of Alfven harmonics is well-resolved. The waves turn on and off frequently as you can see below.

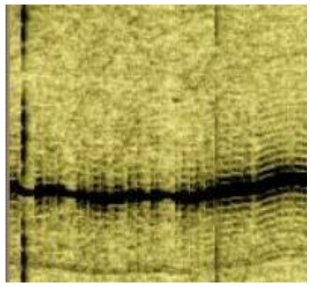

Fig. 4 1 Hz Alfven plasma waves heterodyned with a 60 Hz power grid harmonic. The Alfven plasma wave harmonics show ~ 1 Hz spacing.

The presence of Alfven waves makes the 60 Hz power grid harmonics seem thickened.

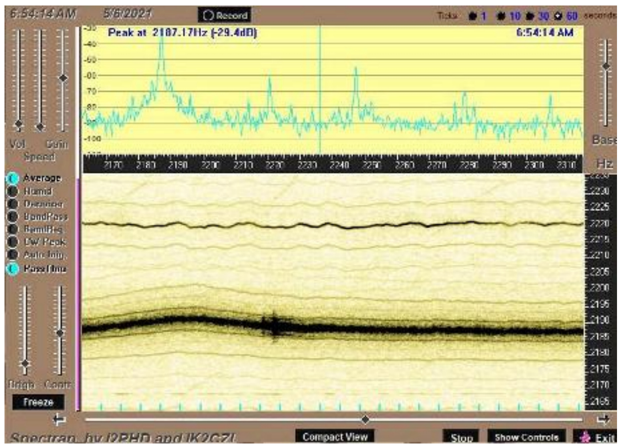

Fig. 5 The unexpected minutes long wavelet, which is a positive electric field. The time marks along the horizontal axis are minutes.

The upward deflected slow wavelet of **Fig. 5** is apparently a hole positive electric field (4), and it peaks before a small earthquake on its downslope shoulder. Note that holes exist only in Earth's crust. Those that cross into the atmosphere or into water drive chemical reactions. The wavelet lasts about 11 minutes. There are no Schumann resonances or Alfven waves associated with the 37th power grid harmonic at 2220 Hz, and the wavelet itself is thus the apparent precursor signal. So, earthquakes appear to be due to a positive hole related phenomenon (4). Schumann impulses also typically begin on the downslope shoulder of a + wavelet. The wavelet - small quake proximity in **Fig. 5** has a low probability of being coincidental.

ISSN number; ISSN 2202-0039

The 2 Hz signal, another unexpected pre-quake signal

In **Fig. 1** the 36th harmonic of the power grid is heterodyned with an approximately 2 Hz signal, which results in two additional signals, one above and the other below the 36th power grid harmonic. Some authors (7) attribute the signal to aseismic slip before an earthquake. It is said that aseismic slip is hard to detect, but the 2 Hz signals in **Fig. 1** are not weak.

Alfven waves can begin when a slow wavelet peaks

In **Fig. 6**, a positive slow wavelet on the seismic baseline climbs to a peak, then begins descending at a slower rate (8). Coincident with the wavelet peak, 1 Hz Alfven waves begin on the 36th power grid harmonic (2160 Hz) and continue until a Mag. 6.7 earthquake in Chile has taken place and begins to fade. As noted earlier, Alfven waves are easily noticed as a thickening of the power grid harmonics (and some of the Alfven harmonics are resolved in **Fig. 6**).

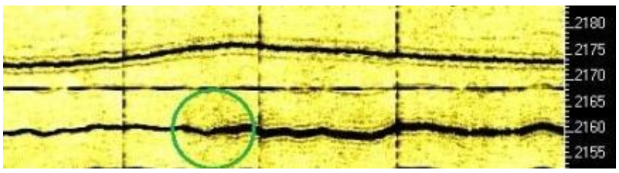

Fig. 6 The Chilean earthquake. Alfven activity begins at the slow wavelet's peak, circled. The wavelet at the top is the seismic baseline. 2160 Hz is a power grid harmonic.

After nearly 38 minutes of continuous Alfven wave activity a second wavelet begins and coincides with the earthquake, giving it upward curvature, similar to the seismic wavelet in **Fig. 6**. See **Fig. 7**.

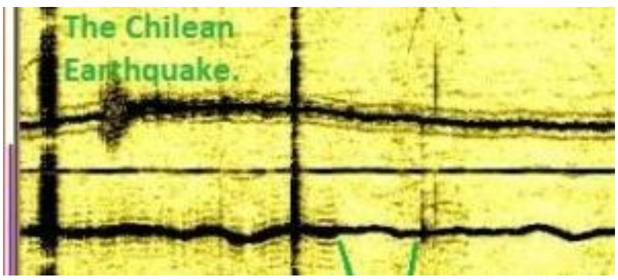

Fig. 7 A coincident quake and a slow wavelet. The quake and the Alfven waves also end together! This has a low probability of being a coincidence.

Do Schumann outbursts also originate near or even coincident with wavelet peaks? Schumann outbursts that lead to earthquakes frequently begin small and increase in amplitude. In fact, the first detectable outburst typically begins on the downward shoulder of the first wavelet. See also **Fig. 8**.

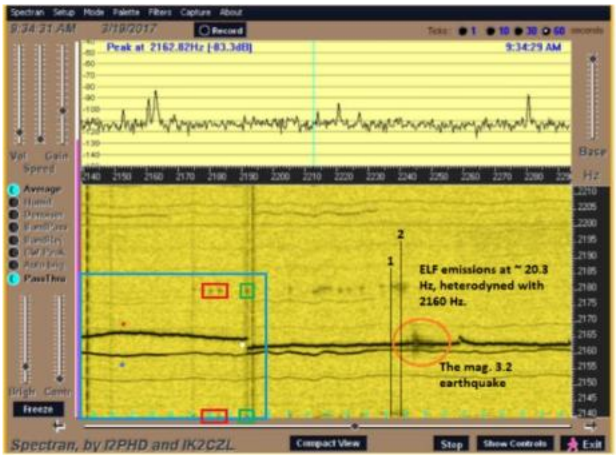

Fig. 8 This is a small New Madrid Seismic Zone earthquake. The first Schumann signal is in a faint dark strobe just left of the upper red rectangle. The blue-green dot marks the 36th power grid harmonic and a smoothing effect from the + charged wavelet. It is smooth because Pc2 is elevated, increasing the corona discharge, thus connecting a larger portion of the grid.

At least some of the "boom" sounds that seem to originate from below ground are an electrical phenomenon

"Boom" sounds that continue to originate in the region near New Madrid, MO and elsewhere in the world do correlate with seismic activity (9). In **Fig. 8**, owing to the instrument's electric field sensitively, it detects a positive wavelet that peaks beneath the red dot. The blue-green dot marks the 36th harmonic of the power grid. The event just to the right of the white dot is a downward discontinuity (with some overshoot) that very clearly marks the electrical discharge of the wavelet! Coincident with the discharge, a vertical broadband EM strobe involving a ~ 50 Hz frequency range is electrical in nature because it coincides with the discontinuity and the fourth Schumann outburst in the blue-green square. Finally, the second, stronger broadband strobe is delayed by a time that is comparable to the travel time between the quake's location near Bardwell KY and Cotter, AR. That strobe - an acoustic shock wave - would be the "boom." Its audible frequency range is obviously more than 50 Hz. It is a different kind of stagger phenomenon, but one with a delta-t similar to the one of the final Schumann outburst (differences are probably my error in drawing vertical lines 1 and 2).

It should be noted that the second "boom" strobe is the origin of the second signal down from the top of the displayed image, which may be 0.3 Hz Alfven waves coming from the power grid antenna (its wavy, horizontal line has the characteristic Alfven on-off, thickened segments). The event following the white dot is definitely not an earthquake! It could be likened to underground lightning and thunder (10). Also see: (11 and 12).

ISSN number; ISSN 2202-0039

Schumann's seismic stagger

Schumann waves travel at the speed of light, and for all practical purposes, there usually is no need for a time-distance calculation anywhere on earth. On the other hand, seismic waves are a lot slower, which causes the distance-related stagger between vertical lines 1 and 2 in **Fig. 8**, respectively the arrival of the final Schumann outburst and the beginning of the p-wave at the observing seismometer. The stagger is the travel time between the earthquake and the seismometer.

This is also true in the noisy electric discharge event but take note that the first broadband strobe begins a little before the discontinuity. The two cases of stagger agree rather closely.

Schumann's teardrops

The final Schumann outburst before an earthquake turned out to be interesting. It is generally larger than preceding outbursts and more or less pointed on its left end (see Fig. 9, the final Schumann outburst). It looks like a teardrop laying on its side! It is an image of the earthquake, but it is a blurred one. P-waves have smaller amplitudes than s-waves or surface waves, and p-waves also arrive first. Thus, the left end is smaller.

Final Schumann outbursts might be used in quantitative studies of the percentage of Schumann outbursts that actually lead to quakes. It might be easier than trying to search through seismological archives on a global scale.

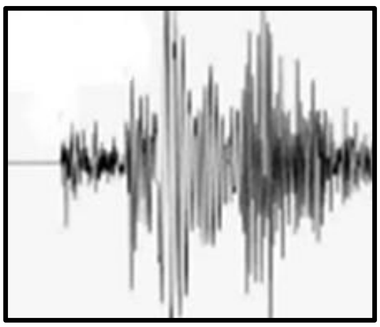

Fig. 9 P-waves have the least amplitude and surface waves are the largest. Blur the **Fig. 9** image and you'll have the teardrop shape: narrow on the left and bulging on the right.

Schumann's machinegun

In **Fig. 8**, along the row of Schumann outbursts belonging to the 2160 Hz power grid harmonic, near the middle, there is one long sequence that looks like a single line owing to more frequent outbursts, i.e., outbursts a few seconds apart. It is not a straight line, but its waviness matches with that of the 36th power grid harmonic. Needless to say, it is a strong indication of an oncoming quake.

Other variables

There are two vertical dark strobes in **Fig. 7**, and their origin remains unknown at this writing. They frequently show waves along their vertical dimensions. They are dark only in negative images, in which the dominant color is yellow. The strobes are white in positive images, in which a blue color is dominant. Blue is a terrible waste of black printing ink!

In **Fig. 8** the Mag. 3.2 earthquake is followed by a small positive discontinuity, and negative discontinuities show up in other examples. These may be due to charge adjustment following seismic events, but that is not a known explanation.

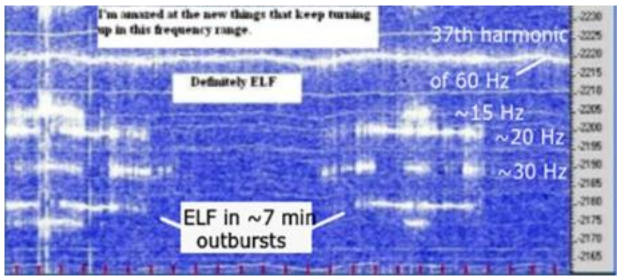

Fig. 10 These Schumann signals occurred on December 4, 2012, and a Mag. 7.3 earthquake occurred in the Pacific Ocean near Miyagi Japan on December 7, 2012. These signals could have been the precursors of that quake, but it isn't established. The second heterodyne is just above the 37th power grid harmonic. Schumann outbursts, possibly before a large earthquake.

This example is a reminder that if we are looking for a workable way to predict quakes for the sake of saving lives, we should focus on large quakes rather than small ones, like **Fig. 8**. The recording in **Fig. 10** is fairly lit up with activity, including "machinegun-like" outbursts. Twenty Hz is close to the 3rd harmonic, but 15 Hz is anomalous (14 Hz is expected for the second harmonic). Similarly, 30 Hz is larger than the expected 27 Hz, 4th harmonic. The ~ 7-minute outbursts also have an interesting vertical pseudosymmetry, waiting to be explained. This activity might be pre-quake signals for a Japanese quake. I hope it isn't murmuring from the New Madrid Seismic Zone. It might be!

The methods used here probably apply to other seismic phenomena.

ISSN number; ISSN 2202-0039

Conclusions

1. The author did not intentionally create sensitivity to electric fields and was not even aware that unshielded seismometers were also rather sensitive to electric fields, which was a Godsend. The original question was about the reality of pre-quake Alfven and Schumann signals. But the choice of using a 2D spectroscopic method was intentional, based on the author's prior involvement with 2D nmr spectroscopy. 2D and 3D spectroscopy, usually based on Fourier transform mathematics, are powerful methods for untangling variables, and 2D worked well in this case, removing the criticism about unshielded seismometers. The outcome included the intended detection of pre-quake Schumann and Alfven outbursts and clearly revealed the considerable involvement of electric field effects in seismic phenomena.

2. The slow wavelets are positive electric fields, apparently based on positive holes that come and go in the Earth's crust, in agreement with Freund's theory (4). Holes exist only in the Earth's crust. They are not actual particles, but lattice defects - locations where electrons or a surplus of positive charges could exist.

3. Before going into seismic issues, the power grid antenna is of interest because it brought some surprises. In **Fig. 1**, most of the right-hand side shows the normal hunting effect of "waviness," the coronal discharge is due to Pc1, and Pc2 is minimal or near zero; but the left-hand side has, for want of a name, a "smoothing" effect, and it occurs beneath a shallow wavelet. In that case, the additional electric field and corona discharge of Pc1 + Pc2 apparently links a portion of the grid into a single conductive entity and thus averages at least part of the grid. That would be a cooperative phenomenon! Smoothing effects are also evident in **Figs. 2 and 8.**

4. Alfven plasma waves can **begin at the peak of a slow wavelet,** and this may also be true for Schumann outbursts, with the understanding that **Schumann outbursts begin weak and become more intense with time**. **Fig. 6** shows the beginning of **Alfven plasma waves at the peak of a + charged wavelet, and those plasma waves do not end until the quake settles down.** Thus, a **critical point apparently happens at the peak of a + wavelet, where either Alfven plasma waves begin or the Schumann process starts (or both)**. The choice probably **depends on the kind of rocks in the seismic crevices**. The relative quiet of the pre-quake period makes sense to me as a **pressure build-up based on electron-electron repulsion from the significant congregation of electrons trapped in seismic crevices**. The material enclosed in the crevice would be a type of plasma i.e. ionized gas that has been documented to precursors earthquakes by many (4). If the crevice turns out to be too weak to reach a quake's energy barrier, then the result is probably the electric "boom" phenomenon of **Fig. 8**. But you notice that **Fig. 8** had another crevice that produced an earthquake! (this is just one interpretation)

5.Schumann outbursts that lead to earthquakes also become more frequent with passing time. Could this property, along with the one in #4, above, be the basis for a five-minute warning time?

6. The "boom" sounds associated with seismic activity in the New Madrid Seismic Zone, and elsewhere, are (or at least in some cases) may be the result of an electric phenomenon caused by the complete discharge of a slow wavelet! A strobe of noise-like electromagnetic energy, which probably travels at or near light speed, is recorded with a frequency range of at least 50 Hz. That event is clearly electrical based on vertical alignment with the discharge discontinuity and the 4th Schumann outburst (in the green square). Then, after the correct seismic travel time from the quake's location to the seismometer, a shock wave with acoustic frequencies arrives. It is another kind of stagger effect, but the time difference is the same as the Schumann-earthquake stagger. The "boom" event is distinctly not a quake.

7. Schumann precursors of large earthquakes can be very complex! See **Fig. 10**.

8. The electric field effects could include involvement in overcoming the quake's energy barrier at a non-degenerate electron pressure level.

Acknowledgements

Funding Information

Author's Contributions

This study derived from a long-lasting cooperation by the authors. The backbone draft was prepared by the first author, although some ideas resulted from the emergence of long-lasting discussions between all authors.

John's paper about a multivariable SEISMIC-ELECTROMAGNETIC-ELECTRIC FIELD instrument was published about five years ago in AIP Review of Scientific Instruments (2). The paper currently submitted for peer review is about SEVERAL phenomena found by the instrument - an assimilation of what the instrument might do. The original intent was to study possible pre-quake Signals, such as Schumann resonances and Alfven plasma waves, to see if they even happened in the time frame of actual seismic events. They indeed do exist,

ISSN number; ISSN 2202-0039

immediately preceding earthquakes! But what was also found bears on the nature of the earthquake mechanism.

My findings are consistent with a very recent MIT observation that the total energy expended during an earthquake, partitions into about 10% as shaking and 80% as heating! My data also support Freund's theory of an electric earthquake mechanism, where positive holes diffuse outward into bedrock, and electrons are thus trapped in seismic crevices. The resulting electron plasma should reach very high pressures and temperatures, even causing melting of rock. I did not expect to encounter the earthquake mechanism(s) issue when I began this project.

I was a student in good standing at Washington University (St Louis, MO, "WUSTL"). It happened that I attended a USAF Reserve meeting on Stratford Ave. in St. Louis, and SDS students protesting the Vietnam War recognized me. After that I received death threats, about two a week (it is the truth!). It was unbearable, and I left WUSTL with a heavy heart, heading South to the University of Mississippi, where I earned my doctorate. Ole Miss turned out to be a pleasant experience.

John Ricken Wright, Ph.D., 'retired.' I turned 87 this January, and I was a faculty member at Southeastern Oklahoma State U. for 31 years. I also did research at Washington U., St. Louis MO, involving ESR spectroscopy. That was during the 1960s. My work was under Samuel. I. Weissman and Daniel Kohl in the early years of ESR spectroscopy; I did the original characterization of the vitamin E free radical. I also have a strong background in electronics.

Ethics

This article is original and contains unpublished material. Authors declare that there are no ethical issues and no conflict of interest that may arise after the publication of this manuscript.

Acronyms

USA – United States of America
2D - 2 Dimensional
Hz – Hertz
E-fields – Electric Fields
MIT – Massachusetts Institute of Technology
LED – light emitting diode
CMOS - complementary metal oxide semiconductor
FM – frequency modulator
SPECTRAN II - Fourier transform program
AC – alternating current
PL - power losses = Pac + Pc1 + Pc2
Pc1 - normal power dissipation due to corona discharge, less than a 1% loss,
Pc2 - elevated corona discharge because of rain, snow or strong electric fields (as in thunderstorms or the positively charged slow wavelets), and it can cause a 3% power loss (or even higher) from the grid.
Pac - about 5-7% of the total loss, from resistive heating in the AC wires and transformers
AI – artificial intelligence
UTC – Universal Time Coordinates
MO – Missouri
EM - electromagnetic
KY – Kentucky
AR - Arkansas
Mag – magnitude
nmr – nuclear magnetic resonance
3D – 3 Dimensional
AIP - American Institute of Physics
ESR - Electron Spin Resonance – "Spectroscopy"

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2. A seismometer that can be used to study pre-quake signals, John R. Wright, Rev. Sci. Instrum., 93, 075103 (July 6, 2022) https://doi.org/10.1063/5.0070885

3. The Properties of Those Ultra-Low Frequency Electromagnetic Signals Associated with Earthquakes, John R. Wright and Bruce Leybourne, New Concepts in Global Tectonics Journal, Volume 13, Number 7, September 2025 (ISSN number; ISSN 2202-0039) Link https://www.ncgtjournal.com

4. Pre-earthquake signals, Part I: Deviatoric stresses turn rocks into a source of electric current, National Hazards Earth Systems Sciences , Friedemann Freund, National Aeronautics and Space Administration, September 2007 7(5) DOI:10.5194/nhess-7-535-2007 License CC BY 4.0

5. The AI opinion: A corona discharge can exhibit a "metal-like" behavior by creating a region of ionized, highly conductive gas (plasma) that effectively acts as an extension of the conductor from which it emanates. Wikipedia has much more technical detail: https://share.google/ctqfcODSDsZCEih7J

6. Collective nonlinear dynamics and self-organization in decentralized power grids Dirk Witthaut, Frank Hellmann, Jürgen Kurths, Stefan Kettemann,

Hildegard Meyer-Ortmanns, and Marc Timme, Rev. Mod. Phys. 94, 015005 – Published 28 February, 2022 DOI:https://doi.org/10.1103/RevModPhys.94.015005 The power grid is the source of several cooperative phenomena.

7. The 2 Hz continuous signal, and others, may be due to aseismic slipping. See: Prevalence of Repeating Earthquakes in the Continental Crust and Subducting Slabs: Triggering of Earthquakes by Aseismic Slip, Junichi Nakajima, Akira Hasegawa, JGR Solid Earth, First published: 01 February 2023, https://doi.org/10.1029/2022JB024667

8. The shallower descending slope of the wavelet in **Fig, 6** reminds the author of the energy budget concept, See the 'budget' concept in reference (3), above…

9. People in the New Madrid Seismic Zone are still hearing boom sounds, and they associate them with small earthquakes. The New Madrid area newspaper most likely to carry stories of such events is Standard Democrat https://www.standard-democrat.com. But don't expect "sounds" activity every month! "…Most of the booms that people hear or experience are probably the result of human activity, such as an explosion, a large vehicle going by, nearby construction, or sometimes a sonic boom, but there have been many reports of booms that cannot be explained by man-made sources. Some of those booms are associated with a variety of interesting natural phenomena, including earthquakes."

10. Underground Lightning - A Possible Earthquake Occurrence Mechanism and Early Warning, Su jianfeng (sujf@nssc.ac.cn) Chen hai (chenhai@nssc.ac.cn) Research Article Keywords: Atmospheric Electric Field, Geoelectric Field Anomaly, Underground lightning, Exploration of earthquake phenomena Posted Date: November 17th, 2022, (Researchgate) Abstract of Underground Lightning: "Through the comparative and analysis of the positive anomaly characteristics of atmospheric electric field before lightning and terrestrial electric field before earthquake, this paper proposes that one of the mechanisms of earthquake generation is underground lightning, that is, huge underground electrical energy accumulates and releases instantaneously, and electrical energy is converted into mechanical energy instantaneously, causing the rupture of the solid structure of the underground lithosphere to form an earthquake. Based on this mechanism, the feasible methods of earthquake early warning are explored."
DOI:https://doi.org/10.21203/rs.3.rs-2273170/v1
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12. Earthquake Booms, Seneca Guns, and Other Sounds (USGS Document) By USGS Earthquake Hazards Program This is a subset of our downloadable software for earthquake research. USGS uses GitHub for all new software development, as well as open-sourcing older software as time allows. For a comprehensive listing of all available software, see how our applications work, and to collaborate with us, please go to USGS GitHub.

SUPPLEMENTARY INFORMATION

1. An instrument that records a single variable has one degree of freedom (counting instruments), and a 1D plot works fine.

   If there are two distinct variables, use a 2D FT recording to untangle the variables, and the plotted coordinates (2) have to be orthogonal.

   If there are three variables, like seismic, electric field and electromagnetic, use a 3D FT recording to completely untangle the variables, and the three coordinates have to be orthogonal. However, in the case of my instrument, both seismic and electric fields come from the same instrument, and the FT processing will not fully untangle them, but you can cheat a little at times. For example, seismic and electric fields are indeed in the time domain, but time often separates seismic and electric field effects. There is a pattern; a + wavelet records first, followed by a sequence of Alfven waves or Schumann resonances or both (on the frequency axis). Then comes the quake. A large quake can be superimposed with a second + wavelet, which causes the quake signal to curve upward, like an arch, i.e., curved like the slow wavelet (See **Fig. 7**) But even small quakes can show a "smoothing" phenomenon. Multivariable instruments often find additional variables. It happened in this project!

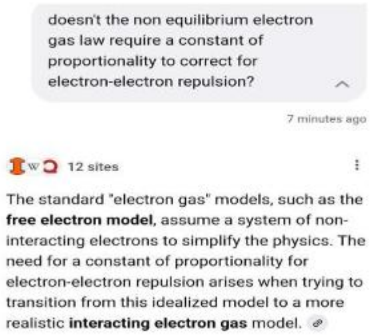
2. Earthquakes are obviously substantially mechanical. But is there any reason why two kinds of forces can't interact to push a quake over its energy barrier? With a non-neutral electron plasma pushing outward from the interior of a seismic crevice and the rapid melting observed by MIT Scientists, the quake might happen. But many dispute the possibility of high electron pressure in seismic crevices. The pressure estimates also vary quite a bit. Before anything happens the

ISSN number; ISSN 2202-0039

bedrock electrons drift very slowly, about 1 mm/s (see the AI opinion, below*), but that situation changes when stress builds up around the seismic crevices (they probably are plural!). A positive hole then moves outward with a velocity typically of 3.0 and 6.5 km/s while the trapped electron pressure builds up in a crevice, a brute force that should indeed create rapid resistive heating and melting from electrons trying to get away from each other. The non-degenerate electron gas law gives an estimate of the pressure build-up, where P is pressure, ne is electron number density, kB is the Boltzmann constant and T is absolute temperature:

P = ne kB T

But note that this simple equation has no electrostatic variables. The purpose of the electron plasma model, above, is only the starting point; it entirely ignores coulomb forces (!). The author thus asked for an AI opinion, and the answer was as follows:


doesn't the non equilibrium electron gas law require a constant of proportionality to correct for electron-electron repulsion?

7 minutes ago

12 sites

The standard "electron gas" models, such as the **free electron model**, assume a system of non-interacting electrons to simplify the physics. The need for a constant of proportionality for electron-electron repulsion arises when trying to transition from this idealized model to a more realistic **interacting electron gas** model.

Also, a realistic model is clearly a non-trivial task. Neither is a simple constant of proportionality likely to describe a complex plasma. But it is certain that when stress builds up and positive holes begin diffusing outward, the trapped electrons ought to cause a dramatic increase in the crevice temperature and pressure. Electrons do repel each other!

Melting may have a lubricating effect, thus decreasing the quake's energy barrier. The left to right progression of increasing Schumann wave amplitude, along the time axis in **Fig. 3**, may be evidence of the rapid heating.

Ponder the fact that a small earthquake follows the peak of the + wavelet in **Fig. 5**. The positive electric field that peaked before the quake suggests the possibility that trapped electron pressure building up in the seismic crevice(s) might have facilitated the quake.

*Holes and electrons move away from each other due to diffusion from high to low concentration. In semiconductors this is what creates a depletion region. But with further charge separation comes an electrostatic attraction.

A more appropriate equation has to take Coulomb forces into account, maybe something resembling:

P = (ne kB T) + f (q, etc.),

where the second term probably contributes to more pressure and heat than the first term.

3. See the MIT findings here:


MIT geologists discover where energy goes during an earthquake

JENNIFER CHU | MIT NEWS • SEPTEMBER 16, 2025

Categories: Landscapes + Planetary Interiors, Natural Hazards, Research

"The ground-shaking that an earthquake generates is only a fraction of the total energy that a quake releases. A quake can also generate a flash of heat, along with a domino-like fracturing of underground rocks. But exactly how much energy goes into each of these three processes is exceedingly difficult, if not impossible, to measure in the field.

Now MIT geologists have traced the energy that is released by "lab quakes" — miniature analogs of natural earthquakes that are carefully triggered in a controlled laboratory setting. For the first time, they have quantified the complete energy budget of such quakes, in terms of the fraction of energy that goes into heat, shaking, and fracturing.

They found that only about 10 percent of a lab quake's energy causes physical shaking. An even smaller fraction — less than 1 percent — goes into breaking up rock and creating new surfaces. The overwhelming portion of a quake's energy — on average 80 percent — goes into heating up the immediate region around a quake's epicenter. In fact, the researchers observed that a lab quake can produce a temperature spike hot enough to melt surrounding material and turn it briefly into liquid melt."

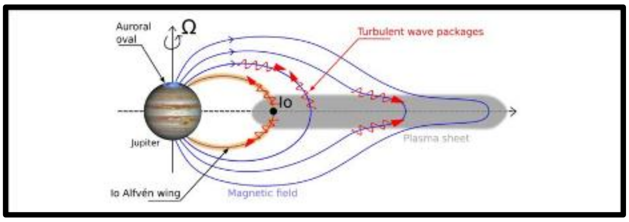
4. Compare these velocities:

Electron drift, normal conditions, is very low - about 1 mm/s. But that will increase markedly when electron trapping begins in the crust, caused by positive holes escaping the crevice, and heating begins. Positive hole drift in the Earth's crust is typically between 3.0 and 6.5 km/s. Electric field changes in the Earth's crust are nearly at light speed. Alfven wave propagation at Earth conditions, is roughly 1,000 km/s, (about 12 s to the antipode). Added comments: The MIT study, which is fairly recent, convinces me that I'm on the right track.

A trapped electron plasma in a seismic crevice is about the only thing that could partition the dissipated quake energy into 10% shaking and 80% heating! The Schumann property of miniscule outbursts progressing to more frequent, high amplitude outbursts also speaks of intense, intermittent heating...

Alfvén waves and Schumann resonance

Alfvén waves travel within a medium of magnetized plasma and are related to a restoring force of magnetic tension typically in the mHz to a few Hz, i.e. ULF/ELF) frequencies. Alfvén wave may propagate along geomagnetic field lines transporting energy and momentum rom the solar wind into the magnetosphere–ionosphere system and are closely associated with field-aligned (Birkeland) currents.



While Schumann resonance travels within the Earth–ionosphere electromagnetic cavity medium and are related to forces of EM wave reflection between Earth's surface and ionosphere at Fundamental frequency: ~7.83 Hz (harmonics at ~14, 20, 26 Hz), Primarily driven by global lightning activity and represent standing EM waves, not plasma waves.

Alfvén waves and Schumann resonance are not directly resonant

Alfvén plasma wave and Schumann resonance are different phenomena and do not couple directly, the relationship is modulatory, not resonant. Alfvén Waves propagate through magnetized (MHD) plasma as field-aligned currents driven by solar wind and magnetospheric dynamics related to the field line length and wave speed.

While Schumann resonance propagates within the atmosphere-ionosphere EM cavity along spherical waveguides driven by lightning related to the Earth–ionosphere cavity size.

Even when frequencies overlap near ~8 Hz, the dispersion relations and boundary conditions are entirely different. Frequency coincidence does not equal physical resonance. Although they are indirectly linked through

a.) the global electrical circuit,
b.) ionospheric conductivity,
c.) and geomagnetic activity.

Birkeland currents and the global electrical circuit

Alfvén waves drive field-aligned currents. These currents close through the ionosphere, and atmosphere subtly influencing fair-weather electric field and ELF background noise floor. Thus, Alfvén waves influence the boundary conditions, not the resonance itself.

Ionospheric conductivity as the bridge

Alfvén waves modulate ionospheric electron density, altering reflection height of ELF waves, the cavity Q-factor along with the Schumann resonance amplitude and linewidth. While Schumann resonance responds passively to magnetospheric forcing.

Geomagnetic storms - Schumann amplitude changes

Strong Alfvénic Poynting flux during enhanced auroral precipitation leads to an increased D-region ionization, along with a shift in Schumann resonance frequencies with enhanced damping or amplification. This is well observed during geomagnetic storms but remains a secondary effect.

What is *not* supported physically

Schumann resonance is ***not*** being driven by Alfvén waves. Does ***not*** share an "Earth heartbeat" resonance. And is ***not*** phase-locked coupled between magnetospheric ULF waves and Schumann modes. These ideas fail under:

- Maxwell–MHD separation
- Energy density mismatch
- Lack of mode conversion mechanism

Correct physical framing is important

Schumann resonance is an atmospheric EM resonator and is highly sensitive to ionospheric state. While Alfvén waves are plasma energy transport modes. Their interaction occurs only through ionospheric conductivity and current closure. This distinction is critical in space-weather–to–geosystem coupling models.

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Volume 14, Number 3, March 2026

ISSN number; ISSN 2202-0039

Relevance to deep Earth / induction modeling

In global induction or "stellar transformer" frameworks Alfvén waves modulate ionospheric properties, not atmospheric resonances directly.

- Alfvén waves = input energy modulation
- Ionosphere = impedance matching layer
- Schumann resonance = diagnostic observable, not a driver

This makes Schumann resonance useful as a proxy indicator, not a causal agent. Thus, frequency coincidence does not imply resonance or coupling.

Alfvén Waves and Ionospheric Conductivity

Alfvén waves have an indirect but physically robust relationship to ionospheric conductivity. Alfvén waves deposit energy into the ionosphere via Poynting flux and auroral particle precipitation, modifying electron density, conductivity profiles, and effective reflection height of ELF waves. Alfvén waves modulate ionospheric properties, not atmospheric resonances directly.

Ionospheric Conductivity and Schumann Resonance

Direct environmental control relationship of Schumann resonance frequencies and amplitudes depending on, ionospheric height, conductivity gradients, and D-region ionization. While changes in conductivity alter, resonant frequency, linewidth (Q factor), and signal amplitude. Thus, Schumann resonance is highly sensitive to ionospheric state.

Relationships between Alfvén Waves, Geomagnetic Storms, and Schumann Resonance

During solar storm-driven modulations, geomagnetic storms increase Alfvénic energy flow into the ionosphere enhancing ionization and conductivity. Observations include frequency shifts, amplitude modulation, and increased damping of Schumann modes. Thus Schumann resonance responds passively to storm-time magnetospheric forcing.

Alfvén Waves and Birkeland Currents

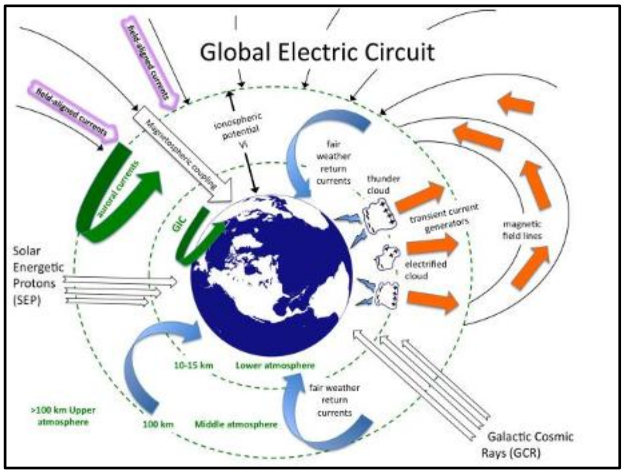
Direct causal relationships include Alfvén waves carrying and modulating field-aligned currents. These currents close through the ionosphere and represent the primary mechanism for magnetosphere–ionosphere energy transfer. Thus, Birkeland currents are the current-system manifestation of Alfvén wave dynamics.

Birkeland Currents and the Global Electrical Circuit

Indirect coupling from current closure of field-aligned currents which partially close through the ionosphere, atmosphere, and surface conductivity related to Ground Induction Currents (GICs). This can slightly perturb the fair-weather electric field and atmospheric current density. Thus, magnetospheric currents influence, but do not control the global circuit.

Global Electrical Circuit and Schumann Resonance

These systems and effects have shared environments but play different roles. Both exist in the Earth–ionosphere cavity including deep Earth. While the global circuit sets background conductivity, lightning drives Schumann resonance excitation. Thus, the global circuit affects boundary conditions, not the circuit excitation.



NCGT Journal
New Concepts in Global Tectonics

New Concepts in Global Tectonics Journal
Volume 14, Number 3, March 2026

ISSN number; ISSN 2202-0039

Magnetostriction and Seismogenesis: A New Model for the Generation of Strong Earthquakes Induced by Variations in the Earth's Geomagnetic Field

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Abstract: Recent studies have suggested a correlation between variations in the Earth's geomagnetic field, induced by proton increases in the solar wind, and the occurrence of earthquakes of significant magnitude. However, the mechanisms linking these geomagnetic perturbations to the processes of seismogenesis remain unclear. This study proposes a new model that explores magnetostriction in ferromagnetic materials of the Earth's crust as a possible trigger for the release of seismic energy. Magnetic minerals present in the vicinity of tectonic faults, such as magnetite, ilmenite and pyrrhotite, can undergo mechanical deformations in response to fluctuations in the Earth's magnetic field. These magnetostriction-induced deformations can contribute to the accumulation of stress in rocks already subjected to tectonic stresses, accelerating the fracturing process and causing seismic events of high magnitude.

Keywords: Magnetostriction, M6+ earthquakes, earthquake prediction, geomagnetic activity, Seismogenesis.

Introduction

Understanding seismogenic processes, i.e. the mechanisms that lead to the release of seismic energy in the form of earthquakes, has long been a central topic in seismology. However, despite the progress made in the study of tectonic and rock dynamics, many questions remain about the factors that actually trigger these events, especially for large-magnitude earthquakes. In recent years, the growing attention towards the analysis of seismic precursors, including electromagnetic signals and geomagnetic anomalies, has led to the formulation of new hypotheses that link external phenomena, such as variations in the solar wind, with the triggering of seismic events. In particular, through studies conducted by the authors since 2012, it has been proven that there is a close correlation between proton increases in the solar wind and earthquakes of significant magnitude (M6+) [1-44], this has opened new research perspectives.

A still little explored, but potentially relevant, aspect concerns the role of magnetostriction in materials present in the Earth's crust as a possible seismogenic mechanism. Magnetostriction, a phenomenon through which some ferromagnetic materials change shape or size in response to variations in the magnetic field, has been studied mainly in the industrial field for applications such as transducers [45-47], but its impact on geophysical dynamics has been neglected so far.

However, considering that many ferromagnetic minerals, such as magnetite, ilmenite and pyrrhotite, are commonly present in rocks of the Earth's crust, it is possible to hypothesize that fluctuations of the Earth's geomagnetic field, induced by variations in solar activity, can trigger mechanical deformations near tectonic faults, contributing to the release of seismic energy.

Magnetostriction and ferromagnetic materials in the Earth's crust.

Magnetostriction occurs when the magnetic domains of a ferromagnetic material realign in response to an external magnetic field, resulting in mechanical deformation. This phenomenon, well documented in artificial materials used for electronic devices, may be equally important in natural materials, such as ferromagnetic minerals, which are found abundantly in igneous and metamorphic rocks in the Earth's crust. Minerals such as magnetite (Fe_3O_4), hematite (Fe_2O_3), ilmenite ($FeTiO_3$), and pyrrhotite ($Fe_{1-x}S$), among others, have magnetic properties that make them susceptible to magnetostriction [48-52]. These materials may undergo deformation when exposed to variations in the Earth's geomagnetic field, caused by events such as geomagnetic storms or

NCGT Journal
New Concepts in Global Tectonics
New Concepts in Global Tectonics Journal
Volume 14, Number 3, March 2026
ISSN number; ISSN 2202-0039

increments of charged particles from the solar wind.

Tectonic faults, which represent the sliding edges of the Earth's plates, are highly stressed zones where tensions build up that can lead to earthquakes. The presence of magnetic minerals in these critical zones, combined with deformations induced by magnetostriction, could contribute to creating a mechanism for the sudden release of seismic energy. In the model proposed here, geomagnetic fluctuations, induced by the increase in protons in the solar wind, influence magnetostrictive materials in rocks, causing them to deform. This mechanical deformation could add to the tectonic stress already accumulated, accelerating the process of rock fracturing and leading to the occurrence of an earthquake.

Variations of the Earth's geomagnetic field and solar wind.

Variations in the Earth's geomagnetic field are directly influenced by solar activity. Proton increases, associated with coronal mass ejections (CMEs) and solar flares, can significantly influence the flux of charged particles hitting the Earth, disturbing the geomagnetic field (**Fig 1**).

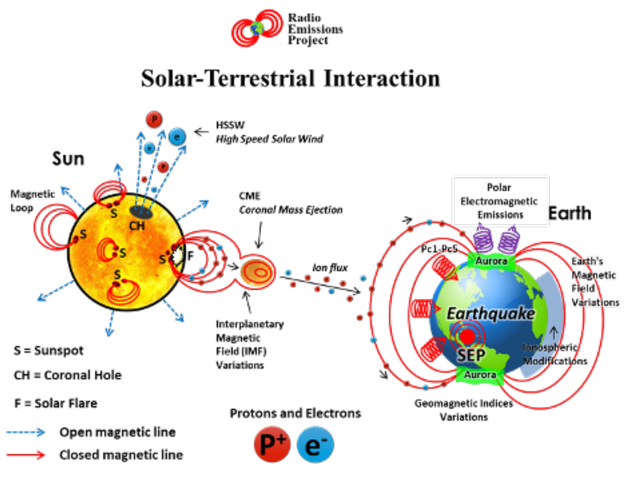

Fig 1 – Solar Ion Flux Dynamics. In the image above, electromagnetic phenomena of solar origin are visible, which increase the density of the solar ionic flux, generating increases in the Earth's geomagnetic field. Credits: Radio Emissions Project.

These variations, commonly known as geomagnetic storms, not only affect radio communications and technological infrastructures, but can also have deeper impacts at the geological level. In fact, variations in the density of the solar ion flux also determine perturbations of the polar electromagnetic emission, of the electrical characteristics of the ionosphere and of the geomagnetic pulsations (**Fig. 1**).

Geomagnetic storms have been observed in conjunction with some large seismic events, suggesting a possible correlation between the two [1] [6] [8] [12] [20-37] [53-56]. The proposed theory explores the possibility that such geomagnetic variations may act as a trigger for earthquakes through magnetostriction of ferromagnetic minerals in rocks. When the geomagnetic field undergoes significant fluctuations, magnetostrictive minerals in rocks deform, placing additional stress on already strained fault planes. This cumulative effect could then accelerate the reaching of the breaking point, releasing the stored energy in the form of seismic waves.

Magnetostriction as a seismogenic mechanism.

The role of magnetostriction as a seismogenic mechanism is a hypothesis that requires an interdisciplinary understanding of the interactions between geomagnetic phenomena and tectonic dynamics. While previous studies have focused on electromagnetic signals and ionospheric anomalies as possible precursors of earthquakes, few have considered the direct role of geomagnetic field variations as physical triggers through interaction with ferromagnetic minerals. Magnetostriction, due to its ability to generate mechanical deformations, provides a potential link between geomagnetic variations and seismic energy release.

The process can be described in three main phases:

1) Tectonic stress buildup: Rocks along a fault line build up stress over time due to the movement of the Earth's plates.

2) Geomagnetic interaction: An increase in protons in the solar wind induces fluctuations in the geomagnetic field, which causes magnetostrictive minerals in rocks to deform through the phenomenon of magnetostriction.

3) Fracture and energy release: Additional mechanical deformations can accelerate the fracturing process in stressed rocks, triggering the sudden release of energy that manifests as an earthquake.

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This work aims to:

To explore, in a purely theoretical sense, the mechanism by which variations in the Earth's geomagnetic field, induced by perturbations such as proton increases in the solar wind, can trigger magnetostriction phenomena in ferromagnetic minerals present in the Earth's crust.

To discuss how magnetostriction can contribute, hypothetically, to the accumulation of mechanical stress along tectonic faults, leading to the release of seismic energy and triggering seismic events, in particular earthquakes of significant magnitude.

To propose a theoretical modeling of the link between geomagnetic variations and the process of seismogenesis, focusing on the potential effects of this mechanism on the dynamics of faults subjected to tectonic stress.

The aim of the work is to present a theoretical hypothesis that can be integrated into future seismological studies, offering new perspectives on the understanding of seismic phenomena in relation to geomagnetic perturbations and their interactions with magnetic materials present in the Earth's crust.

Ferromagnetic Materials in the Earth's Crust and the Magnetostriction Phenomenon

The role of ferromagnetic minerals in the Earth's crust has been the subject of numerous studies due to their peculiar magnetic properties. These materials, particularly sensitive to external magnetic fields, have a distinctive feature: magnetostriction, a phenomenon that involves the mechanical deformation of the material in response to variations in a magnetic field. When subjected to geomagnetic fluctuations, ferromagnetic minerals can undergo compression or expansion (**Fig. 2**), generating macroscopic deformations in the rocks that contain them [57-64]. This mechanism is of great interest in the context of seismic dynamics, since these deformations can contribute to the accumulation and release of tectonic stress.

The Earth's crust is composed of a wide range of minerals, many of which exhibit magnetic properties that make them susceptible to magnetostriction. Major magnetic minerals include magnetite, ilmenite, hematite, and pyrrhotite, all ferromagnetic elements common in igneous, sedimentary, and metamorphic rocks [63] [65-70]. These materials not only respond to variations in the geomagnetic field, but in certain cases can amplify deformations generated by external perturbations, such as solar storms, through the realignment of their internal magnetic domains.

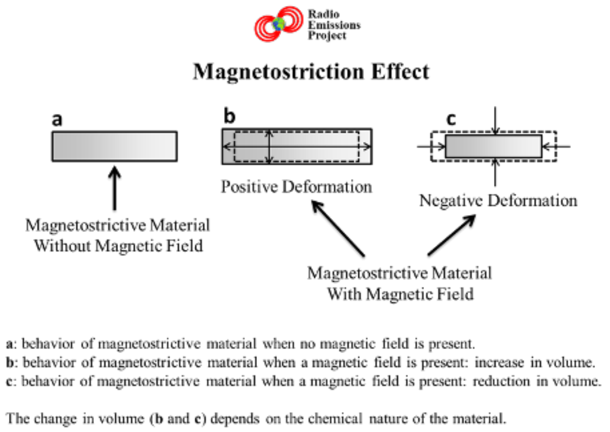

Fig 2 – Magnetostrictive effect. The image above shows the variation in volume of a magnetostrictive material, i.e. sensitive to the magnetic field. The extent of the variation in volume and the type of variation (positive or negative) depends on the chemical nature of the magnetostrictive material. Credits: Radio Emissions Project.

In the context of seismogenesis, the process of stress accumulation along tectonic faults can be influenced by the mechanical and magnetic properties of minerals in the surrounding rocks. The ability of some minerals to deform in response to magnetic variations can increase local stress, further destabilizing fault segments already subject to strong tectonic stresses. This cumulative effect can accelerate the process of rock fracturing, potentially triggering the sudden release of energy in the form of an earthquake.

Geomagnetic disturbances, generated by solar phenomena such as coronal mass ejections (CME) or solar flares, can induce significant fluctuations in the Earth's geomagnetic field. These fluctuations affect the magnetostrictive materials present in rocks, causing a direct mechanical response. Minerals, subjected to these variations, can deform cyclically or undergo internal realignments that cause microfractures. These microfractures can expand rapidly, evolving into macrofractures that contribute to the release of seismic energy.

Of particular interest are minerals such as magnetite, which exhibit a marked sensitivity to magnetic fields and have well-documented magnetostrictive properties. The following list explores some of the major minerals in the Earth's crust that can undergo magnetostriction, and discusses their potential role in the context of geomagnetic disturbances and seismogenesis:

Magnetite (Fe_3O_4)

It is one of the major ferromagnetic minerals found in the Earth's crust. Magnetite is particularly sensitive to magnetic fields and can undergo magnetostrictive deformations.

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Ilmenite ($FeTiO_3$)

Another common ferromagnetic mineral, particularly abundant in igneous and metamorphic rocks. It can exhibit magnetostrictive properties due to its iron content.

Hematite (Fe_2O_3)

Although it is an antiferromagnetic mineral, it can exhibit residual magnetic effects and, under certain conditions, may exhibit minimal magnetostrictive deformations.

Pyrrhotite ($Fe_{1-x}S$)

An iron sulfide that can be magnetic and therefore potentially subject to magnetostrictive deformations under the influence of geomagnetic variations.

Goethite (FeO(OH))

An iron mineral found in sedimentary and metamorphic rocks. Although not strongly magnetic, it may be weakly magnetostrictive.

Limonite (FeO(OH) nH_2O)

An amorphous mixture of iron oxides and hydroxides that may be weakly magnetic. Limonite may respond weakly to changes in magnetic fields.

Chromite ($FeCr_2O_4$)

A ferromagnetic mineral common in ultramafic igneous rocks. Its magnetic properties may contribute to magnetostriction under appropriate conditions.

Pentlandite $(Fe,Ni)_9S_8$

A magnetic iron-nickel sulfide that can deform under the influence of a changing magnetic field.

Troilite (FeS)

Similar to pyrrhotite, troilite is an iron sulfide that, under some conditions, may exhibit magnetostrictive properties.

Cobalt (Co)

Cobalt is found in small amounts in the Earth's crust and has strong magnetostrictive properties, easily deforming in response to changes in the magnetic field.

Nickel (Ni)

Nickel, found in small amounts in rocks, is also an element with strong magnetostrictive properties.

Gahnite ($ZnAl_2O_4$)

Although not magnetic in itself, it can undergo induced mechanical deformation in rocks containing magnetic components.

Jacobsitium ($MnFe_2O_4$)

A magnetic oxide of manganese and iron that may react to changes in the magnetic field.

Franklinite ($ZnFe_2O_4$)

A magnetic oxide of iron and zinc that can exhibit magnetostrictive effects in changing magnetic fields.

Maghemite (γ-Fe_2O_3)

A metastable form of iron oxide with magnetic properties similar to magnetite, capable of undergoing magnetostriction.

Greigite (Fe_3S_4)

Iron sulfide that can exhibit magnetic behavior and respond to changes in the magnetic field with deformation.

Ferrite (various iron and oxygen compositions)

Iron minerals that form ferrites (compounds of iron oxides with various metals) exhibit magnetic behaviors that can contribute to magnetostriction.

Aluminum (Al) – in combination with other ferromagnetic metals

Although not ferromagnetic by itself, in the presence of alloys with iron or other magnetic metals, it can exhibit magnetic properties.

Titanomagnetite ($Fe_{3-x}Ti_xO_4$)

A mixed oxide of iron and titanium that can exhibit significant magnetic properties, potentially contributing to magnetostriction.

Spinels (group of minerals)

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The spinel group of minerals includes materials such as magnetite, chromite, and franklinite that have magnetic properties and may respond to changes in the magnetic field with deformation.

Olivine $(Mg, Fe)_2SiO_4$
Is a magnesium iron silicate with the chemical formula . It is a type of nesosilicate or orthosilicate.

Perovskite $CaTiO_3$

Is an orthorhombic calcium titanium oxide mineral composed of calcium titanate (chemical formula).

An intriguing correlation of these wavelengths to several well documented seismic discontinuities is significant, especially at 410 km (olivine-spinel phase change) and 660 km (spinelperovskite phase change); the latter discontinuity separates the upper and lower mantle.

In the Earth's crust, ferromagnetic materials are present in varying average percentages, with iron (Fe) being the most abundant element, making up about 5 percent of the crust. This makes iron one of the key elements in understanding the magnetic properties of rocks. Titanium (Ti) follows with an average percentage of 0.57 percent and is often present in minerals such as ilmenite. Manganese (Mn), at 0.1 percent, is another important element that contributes to the magnetic properties of minerals. Chromium (Cr), found at 0.01 percent, is common in ultramafic rocks and contributes to magnetic phenomena. Nickel (Ni), present at 0.008 percent, and cobalt (Co), at 0.003 percent, are less abundant, but still play a significant role in magnetic processes [70-78]. According to the authors, these elements, when combined in ferromagnetic minerals, can be subject to phenomena such as magnetostriction, thus influencing geological dynamics, including those related to seismogenesis.

When magnetostrictive materials in the Earth's crust are subjected to changes in the geomagnetic field, such as those caused by solar storms or other geomagnetic disturbances, they can undergo mechanical deformation. In particular, changing magnetic fields affect the magnetic domains in ferromagnetic materials, forcing them to realign. This realignment causes the material to compress or expand at the microscopic level, which can propagate as macroscopic deformations in the bedrock [79-88].

In the context of seismogenesis, these additional deformations could contribute to destabilizing rocks subjected to tectonic stress. The influence of materials such as magnetite, which is commonly found in igneous and metamorphic rocks, is particularly significant, since their strong magnetic effects can amplify deformations induced by geomagnetic fluctuations, potentially accelerating the process of rock fracturing and contributing to the release of seismic energy.

Interactions between Geomagnetic Field Variations and Magnetostriction: A Mechanism for Seismogenesis

Variations of the Earth's geomagnetic field, mainly induced by solar-induced events such as coronal mass ejections (CMEs) or solar flares, can cause significant perturbations in the local magnetic field [89-98]. The authors have already shown that potentially destructive seismic activity is always preceded by an increase in the density of the solar proton flux that can determine gradual increases in the Earth's geomagnetic field, perturbations and geomagnetic storms of various degrees [1] [6] [8] [12] [20-37] [53-56] [99-120].

These fluctuations are particularly evident during geomagnetic storms generated by large and intense increases in the proton density of the solar ion flux that interacts with the Earth's magnetosphere. The result of these interactions is a transient variation (more or less intense) of the Earth's geomagnetic field that can have effects not only on the atmosphere and technological infrastructures, but also at the geological level.

During an increase in proton density in the solar wind, the geomagnetic field can undergo rapid fluctuations, causing the deformation of magnetostrictive materials in the Earth's crust. These deformations have the potential to add additional mechanical stress to rocks already under high tectonic stress, potentially accelerating the fracturing process. In the case of tectonic faults, where stress slowly builds up due to the movement of the Earth's plates, even small additional deformations induced by magnetostriction can act as a trigger for the release of the accumulated seismic energy.

The mechanical deformations generated by magnetostriction in ferromagnetic materials are not only microscopic, but can propagate within the surrounding rocks, favoring the formation of microfractures [121-139]. These microfractures can rapidly evolve into macrofractures that, in a highly stressed area, could lead to the sudden release of energy in the form of seismic waves. In this context, variations in the geomagnetic field, therefore, do not simply represent a passive phenomenon, but can act as a trigger for seismic events of significant magnitude.

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An Integrated Approach to Seismogenesis

As mentioned, geomagnetic variations could trigger deformation phenomena in magnetostrictive materials of the Earth's crust, accelerating seismic processes. However, it is plausible that magnetostriction does not act in isolation but competes with other physical phenomena that together influence the processes of seismogenesis. Among these phenomena, a fundamental role could be played by electrostriction, the Lorentz force and other effects associated with the movement of electric charges and fluids inside rocks.

Electrostriction.

Electrostriction is a physical phenomenon by which a dielectric material undergoes mechanical deformation when exposed to an electric field. This deformation is caused by the internal polarization of the material, which orients itself along the lines of the applied electric field. Unlike piezoelectricity, which generates a linear and direct response to deformation, electrostriction is a quadratic phenomenon, i.e. the induced deformation is proportional to the square of the electric field [131-139]. This phenomenon can occur in non-ferromagnetic but dielectric minerals present in the Earth's crust, adding additional mechanical stress to the rocks, especially in fault zones where the concentration of electric charges can be high.

In the context of geomagnetic variations, electrostriction could be induced by electric fields associated with geomagnetic disturbances or by electric charges accumulated in rocks during fracturing processes. These electrostrictive deformations can act in synergy with magnetostriction, contributing to the accumulation and release of seismic energy in stressed rocks.

Lorentz Force and Electric Charges in the Earth's Crust.

Another phenomenon that may interact with magnetostriction and electrostriction in seismogenesis is the effect of the Lorentz force on electric charges in rocks, especially along tectonic faults. The Lorentz force occurs when a charged particle moves within a magnetic field, experiencing a force perpendicular to both the direction of the field and the motion of the charge [140-155]. In fault zones, electric charges can be generated by piezoelectric processes, i.e. the accumulation of electric charges due to the mechanical deformation of rocks under tectonic stress.

This phenomenon is particularly relevant in piezoelectric minerals, such as quartz, which can generate electric fields when subjected to pressure or fracturing. The electric charges generated in this way can interact with the geomagnetic field and be influenced by the Lorentz force, creating complex movements that add further stresses to already stressed rocks. These effects can be amplified by triboelectric and chemical processes, in which contact and friction between different rock surfaces can generate additional electric charges, contributing to the increase in local voltages. [156-160].

Fluid Movements in Rock Pores.

In addition to magnetic and electrical effects, fluid movement in rock pores can be another mechanism contributing to seismogenesis. In fault zones, fluids such as water and gases present in rock pores can be pushed under pressure in response to tectonic movements and variations in the geomagnetic field. These fluids can migrate through fractures and pores, modifying the internal pressures of rocks and influencing their mechanical strength [161-170].

Fluid movement can generate pressures that act directly on rocks, promoting the formation of microfractures. These fluids, especially if conductive, can also interact with the electric and magnetic fields present in faults, amplifying electrostrictive and piezoelectric effects, as well as the Lorentz force. Furthermore, the presence of fluids in rocks can alter their mechanical properties, reducing their strength and facilitating the fracturing process.

Magnetostriction

Internally, ferromagnetic materials have a structure that is divided into domains, each of which is a region of uniform magnetization. When a magnetic field is applied, the boundaries between the domains shift and the domains rotate; both of these effects cause a change in the material's dimensions. The reason that a change in the magnetic domains of a material results in a change in the material's dimensions is a consequence of magnetocrystalline anisotropy; it takes more energy to magnetize a crystalline material in one direction than in another. If a magnetic field is applied to the material at an angle to an easy axis of magnetization, the material will tend to rearrange its structure so that an easy axis is aligned with the field to minimize the free energy of the system. Since different crystal directions are associated with

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different lengths, this effect induces a strain in the material. [171]

The reciprocal effect, the change of the magnetic susceptibility (response to an applied field) of a material when subjected to a mechanical stress, is called the Villari effect. Two other effects are related to magnetostriction: the Matteucci effect is the creation of a helical anisotropy of the susceptibility of a magnetostrictive material when subjected to a torque and the Wiedemann effect is the twisting of these materials when a helical magnetic field is applied to them.

The Villari reversal is the change in sign of the magnetostriction of iron from positive to negative when exposed to magnetic fields of approximately 40 kA/m.

Considering the interaction between these phenomena, a complex picture emerges in which magnetostriction, electrostriction, Lorentz force, piezoelectricity and fluid motion combine to influence the process of accumulation and release of seismic energy. Geomagnetic variations can act as a catalyst that amplifies or triggers the accumulated stresses in rocks, leading to the sudden release of energy in the form of an earthquake.

The hypothesis proposed here focuses on the interaction between these various mechanisms, suggesting that none of them act in isolation, but rather that it is the combination of these physical phenomena that determines the triggering of seismic events. Future research could further explore the integration of these phenomena, with laboratory experiments and numerical modeling that could provide new insights into the mechanisms underlying seismogenesis and improve earthquake prediction capabilities.

Discussion

The model proposed in this work provides an innovative interpretation of the mechanisms of seismogenesis, suggesting that geomagnetic variations induced by the solar wind can act as triggers for high-magnitude earthquakes through the phenomenon of magnetostriction in ferromagnetic materials of the Earth's crust. However, as already highlighted, this mechanism does not operate in isolation. Interactions between complex physical and chemical phenomena, such as electrostriction, the Lorentz force, the piezoelectric effect and the movement of fluids in rocks, also contribute significantly to the process of seismic energy release.

Magnetostriction is confirmed as a crucial factor, particularly in tectonic areas where ferromagnetic minerals, such as magnetite and ilmenite, are present. Their sensitivity to variations in the geomagnetic field could be the starting point for a new understanding of the link between solar activity and seismogenesis. Empirical observations of correlations between geomagnetic storms and large earthquakes suggest that geomagnetic fluctuations not only influence the Earth's atmosphere, but can also induce internal deformations in rocks, accelerating the fracturing process.

On the other hand, electrostriction phenomena and the Lorentz force introduced a dynamic that integrates the contribution of electric charges within rocks. Electric voltages, generated through piezoelectric or triboelectric processes, can increase local mechanical stress, adding complexity to the physical interactions that lead to the release of seismic energy. The presence of electric charges in faults, influenced by the Lorentz force induced by geomagnetic variations, could provide further evidence of the link between electromagnetic processes and seismogenesis. This aspect requires further experimental investigations to verify the scale and impact of these forces on rocks subjected to tectonic stress.

Fluid movement in rock pores is also a key element that interacts with electrical and magnetic processes, modifying the mechanical properties of rocks. Fluid migration, in response to geomagnetic variations or tectonic movements, can alter pore pressure, facilitating fractures. In addition, conductive fluids can amplify the effects of electric fields generated through piezoelectric or electrostrictive processes.

Overall, this work highlights the need for a multidisciplinary and integrated approach to understand the mechanisms underlying seismogenesis. While magnetostriction provides a solid theoretical basis to explain the interaction between geomagnetic variations and seismic activity, the integration of other physical and chemical phenomena can provide a more complete view of the processes that lead to the release of seismic energy.

Limitations of the proposed model

It is important to highlight that, although the theoretical model presented offers a plausible explanation of the interactions between geomagnetic phenomena and seismogenesis, some limitations and areas of uncertainty remain. For example, the complexity of the interactions between the different proposed phenomena requires further experimental verification and numerical modeling to determine exactly the relative contribution of each process.

Furthermore, the difficulty of isolating individual factors and their interactions in the natural context,

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where multiple tectonic forces act simultaneously, represents a significant challenge. The phenomenon of magnetostriction is well documented in industrial contexts, but its role in geophysical environments requires further experimental research to fully understand its impact.

Future prospects

The next step will be to develop more complex numerical models that integrate the various phenomena described, verifying their validity with field observations. In particular, laboratory experiments simulating geophysical conditions, including variable geomagnetic fields, the presence of fluids and ferromagnetic materials, could provide further information to refine our understanding of the role of magnetostriction and other processes. The implementation of advanced monitoring networks, capable of detecting geomagnetic, electromagnetic and mechanical variations in real time, could provide a solid empirical basis for testing these hypotheses.

Conclusions

Several studies have already highlighted a correlation between intense geomagnetic events and large magnitude (M6+) earthquakes [1] [6] [8] [12] [20-37] [53-56], but the mechanism underlying this relationship remains largely poorly understood. The present work proposes magnetostriction as a plausible mechanism that could explain how variations in the geomagnetic field, induced by proton increases in the solar wind, can directly affect seismogenesis. The suggested model integrates advanced knowledge on solar activity and on the geomagnetic interaction with terrestrial ferromagnetic materials, such as magnetite, ilmenite and pyrrhotite, offering a new perspective in the study of earthquakes.

Geomagnetic fluctuations can induce mechanical deformations in magnetostrictive minerals present in rocks, triggering microfractures that, in already stressed fault zones, could lead to the sudden release of energy in the form of earthquakes. However, magnetostriction may not be the only factor at play. Other physical phenomena, such as electrostriction, the Lorentz force and the movement of fluids in the pores of rocks, could act in synergy, contributing to a complex picture of geophysical interactions. This multidisciplinary approach highlights how seismogenesis is influenced by a series of electrical and magnetic processes, all linked to variations in the Earth's geomagnetic field.

Although magnetostriction provides an interesting hypothesis, there are still many aspects to be verified through experimental studies and numerical modeling. For example, the precise quantification of the effect of magnetostriction in ferromagnetic rocks and its impact on fault dynamics is a research area still under development. Furthermore, the interaction between magnetostriction and other physical processes, such as piezoelectricity and electrostriction, needs further studies to better understand the role of each phenomenon in promoting seismic triggering.

In conclusion, the link between geomagnetic variations and magnetostriction in ferromagnetic materials represents a new and promising research direction to improve the understanding of seismogenesis. If verified, this hypothesis could lead to the development of new predictive tools for earthquakes, based on geomagnetic monitoring. Such tools could significantly increase the ability to anticipate earthquakes of significant magnitude, contributing to the mitigation of risks associated with catastrophic seismic events.

The proposed model, which integrates complex physical phenomena and geomagnetic interactions, thus opens the way to new possibilities for seismic forecasting on a global scale.

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NCGT Journal
New Concepts in Global Tectonics

New Concepts in Global Tectonics Journal
Volume 14, Number 3, March 2026

ISSN number; ISSN 2202-0039

Permo-Mesozoic basins, crustal development, biogeography and the global latitude-dependent climate system – a fact-based historical perspective

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Abstract: In today's geoscience research and education, plate tectonics reigns supreme. However, despite its popularity, none of the classical problems in geology have achieved acceptable solution, and expected phenomenological interconnections have become a collection of ad hoc propositions in endless progression. Due to major technological advances, data collection has made a major leap ahead, but coherent understanding of the diversity of data – including the phenological variety and general pulse-like modus operandi of the globe, stands still. Undoubtedly, the accumulation of twisted interpretations is a sign of a false theory. How could a large and important science end up in such a state of incapacity? The dominant answer undoubtedly lies in human factors! Like members in any social activity, researchers are also subject to fashion, whim and other human weaknesses. Or as bluntly stated by Paul Davies (1995): "Each age adopts its particular approach to scientific problems, usually following the trail blazed by certain dominant figures who both set the agenda and define the best methods to tackle it". So, what happens to a science when it seemingly never reaches its high goal? Nothing! Because instilled habitual thinking is often so deep-seated that the problems are considered an integral part of science itself. On this background, this essay is a scholarly historical review of the development of plate tectonics – from its post war II infancy in the mid-50s, after the revival of Wegener's long-disbanded continental drift hypothesis, to today's super-mobile global tectonic state. As early as the early 1960s, a small number of English palaeomagnetists had managed to direct their gaze towards a mobile crustal history. The starting shot had been fired for geophysics' fundamental resurfacing of geology's decrepit state. There was a continuous influx of modernized continental drifters who wanted to join the train for an upheaval of the geological sciences. When the plate tectonic revolution was proclaimed in 1968, all geophysical and marine geological objections had been overheard. A new professional fashion had arisen, so objections were only seen as adjournments. The paradigmatic coup d'état had been effective, even if it stood on shaky professional foundations. But since the answers had been given, there was freedom for ad hoc distortions of both data and interpretations – when observations and critical tests did not match the expectations. An invisible power of opinion had taken control, and so it has continued until today. The mobile rearrangement of world's continental geography, completely without acceptable rules of the road, began with Wegener's late Paleozoic forced placement of the then sub-tropical Antarctica in an alleged polar position in his constructed Gondwana. Therefore, much of this essay is devoted to late Paleozoic and Mesozoic eras, the central time span in his continental drift hypothesis. The main conclusion is: If Wegener had treated the paleoclimate data from the southern land masses in the same straightforward way as he had done in

ISSN number; ISSN 2202-0039

the northern hemisphere, it is likely that Earth evolution sciences would have been radically different from today.

Keywords: Wegener, palaeomagnetism, plate tectonics, politics, human frailties

Background and aims

For more than 50 years, plate tectonics (PT) has had an almost sacral position in the geosciences. In all professional contexts, this model has become so ingrained that hardly anyone can think (or dare) to question it. However, as science is a people-driven activity, an emerging wave of ideological popularity will always be dominated by a few that somehow have obtained 'iconic' status. Thus, in the run-up to the PT revolution, Keith Runcorn (Newcastle) and John Tuzo Wilson (Toronto) were the field's undisputed prominences. As a natural consequence, the growing number of PT converts fell into the new trend mainly because it was safer and more fashionable to adhere to a former anarchist idea which by then was proclaimed as the future of the Earth sciences. Based on the new professional philosophy, the geological sciences were no longer regarded inferior professions limited to small-scale mapping and descriptions – they had acquired a global perspective. And perhaps even more important, being member of a like-minded and excited research community, you don't have to defend your own position.

Any paradigm shift happens in such an unprofessional way, because a mass consent basically has to do with emotions, the principle of repetition, friendship, opinion pressure, and other human traits (e.g., Kuhn 1962/70; Lakatos, 1978; Feyerabend, 1988; Anderson et al., 2007; Brooks, 2012; Bjørkum, 2016: Storetvedt, 2024). Therefore, a healthy development of a science is crucially dependent on the leading figures having led mass research in the right direction. Therefore, if a science is based on wrong presumptions, the result will inevitably be an accumulation of distorted interpretations and a fictitious overall perception – whereupon stagnation becomes the consequence. Nevertheless, genuine scientific breakthroughs have always been a combination of anarchy, confusion and strong resistance (cf. Brooks, 2012). In the same way, mass acceptance of scientific attitudes is also strongly affected by the dulling effect the repetition principle has on the intellect.

If Wegener had not been so attached to wishful thinking regarding the paleogeographic unification of the southern continents but had taken seriously the facts that already were available by then (especially regarding the fossil/palaeoclimate evidence from Antarctica), the geosciences could have taken a radically different path. It is a paradox that the classic problems of the drift hypothesis (see later) never have been cleared up, which again emphasizes the human side of science. In striking contrast to the reality, plate tectonics is frequently labelled 'system science', though ad hoc changes of both basic precepts and critical observations have flourished to such an extent "that we are rapidly returning to the pre-revolutionary days when each corner of the Earth had its own history, only loosely tied to others by general principles" (van Andel, 1985). In the same vein, Wezel (1990) stated that "a radical change of approach is necessary in order to overcome the fragmentation that is characteristic of geology today".

In the late 1960s, Tuzo Wilson published a handful of influential and widely cited PT-related articles. But his frank statements about the miserable state of present-day global tectonics, at the 1992 Wilson meeting in St. John's (Tuzo Wilson, 1992), were probably in part to correct the setback he realized he himself was partly guilty of. Though it is inherent in science that one can be wrong, admitting it requires a strong personality. However, even today, more than 30 years after Tuzo Wilson openly acknowledged that he had written off plate tectonics, the 'Wilson Cycle' (Tuzo Wilson, 1966) is still regarded to have been "enormously important to the theory and practice of geology and underlies much of what we know about geological evolution of the Earth and its lithosphere" (R.W. Wilson et al., 2019). But this laudatory review is nothing more than empty words.

Today's global tectonics is largely characterized by a collection of detached ad hoc assumptions and speculative interpretations. The lack of an explanatory network emphasizes that the principles of PT does not work; thus, the geosciences are without predictive capacities. Without a reasonable structural interconnection within a physical system (like the Earth) we should not pretend to understand its individual components (geological phenomena). Regrettably, classical problems in geology – highlighted by a range of time related dynamo-tectonic events, is no longer in fashion. In their replacement, a myriad of invented continental blocks, micro-blocks and crustal plates, apparently in unrestricted motion, have taken the stage. These invented crustal fragments have then collided building up new continental associations that allegedly have varied through time. In this super-mobilistic scheme, former artificial oceans have been closed during which the invented oceanic crust have disappeared down hypothesized subduction sinks without leaving other than speculative surface traces. In other words, the 'Wilson Cycle' – with opening and closing of fictitious oceans – has become a matter of course. This should remind us that habitual thinking and walking tales are strongly present. It is important to get out of this stuck pattern, in as much as the diversity of facts points in a completely different direction.

This essay is therefore straight to the point and without today's PT-related ad hoc shenanigans. But it is spun out of and based on numerous published works by other scientists. But I look at the available data with fresh eyes and give them simple and straightforward meanings, without the burden of PT-related conjectures and prejudices. The Earth

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Volume 14, Number 3, March 2026
ISSN number; ISSN 2202-0039

is a physical-chemical system whose development seemingly has gone in one direction only – from its origin to its present state (Storetvedt, 2003/23), starting from a cold gas-dominated nebular cloud. For example, the progressive evolutionary path implies that both deep-sea and continental basins have the same time-related origin but differentiated by a major difference in the degree of development. This means, for example, that the small-scale Permian to Mesozoic basins of Central Asia and elsewhere are dynamo-tectonically and temporally closely connected with the evolution of the world's deep-sea basins. Moreover, in the new analysis it is shown that the Pangaea/Gondwana configuration(s) has no basis in facts. The Mesozoic Tethys is back to its pre-PT conception, as an epicontinental and largely endemic seaway along the southern rim of Eurasia. And even more important, all prominent crustal and surface phenomena – including biogeographic and climatic aspects, establish a coherent system.

Dynamo-tectonic machinery in focus

Ever since the Earth's core was discovered (Oldham, 1906), it has been known to have a density deficit relative to pure iron; the iron-rich core has an admixture of some 10-15% by weight of lighter elements. In a straightforward interpretation, this suggests that the core is not completely outgassed. Thus, the simplified but ingrained belief that the Earth began as a molten globe, with subsequent cooling and chemical differentiation, is in dire straits. It is far more likely that the Earth began as a mixture of cold gas (mainly hydrogen) and mineral dust (Cameron, 1962) in relatively fast rotation (Alfvén and Arrhenius, 1976). Furthermore, in the initial stages of planetary consolidation, the probably homogeneous nebular mass must have been affected by dynamic, magnetic, and gravitational forces, resulting in gradual compositional segregation.

Initially, the centrifugal force of rotation was likely the most important sorting mechanism, from which diffuse radial bands of increasing density outwards were initially formed. Radioactive/heavier elements such as uranium and thorium gained prominence in the outer regions of the protoplanet, suggesting that the Archaean crust was characterized by abnormally high levels of radioactive fission with heat generation. In that respect, authors like Richter (1985), Fowler (1990) and Thompson et al. (1995), concluded that heat production from long-lived isotopes was 2-3 times greater than it is today, and that the average heat flux was greater by a similar factor. This is also consistent with the relatively high degree of deformability and plasticity that can be observed in Precambrian gneisses.

On the other hand, the inner proto-Earth probably had an overrepresentation of cold nebular gas – dominated by hydrogen which is by far the most abundant substance in our part of the galaxy (Kaufman, 1988), which gave the primeval Earth an inverse temperature distribution. A starting point dominated by cold nebular gas and thus slow internal mass stabilizing processes is probably the reason why the Earth's core still contains a relatively high proportion of lighter elements. This indicates that degassing of the Earth's core is still in action – a situation which is probably the main reason why it is still a tectonically active planet.

In the outer parts of the gas-dominated protoplanet, incremental coalescence of ferromagnetic planetesimals must have led to heavier concretions for which gravitational influence successively outbalanced the centrifugal effect. Thus, heavier iron-rich masses settled inwards through the less dense gaseous mass, progressively building up a high-density iron-rich core (Storetvedt, 2003/23). The question therefore arises to what extent lighter elements can be incorporated into the core's metal mixtures. Experimental evidence suggests hydrogen a principal alloying element (Badding et al., 1991; Okuchi, 1997; Tagawa et al., 2021), while Fisher et al. (2020) consider carbon the most important lighter constituent. Thus, Gottfried (1990) reasoned that the core probably contains significant amounts of hydride-metal compounds, while the silicate-rich lower mantle must contain a large volume of silicide – notably silicon carbide (SiC).

Whatever the formation mechanism behind the iron-rich core and the silicate-rich mantle, the core-mantle boundary is the Earth's most important physico-chemical transition zone; the lowermost 200-300 km of the mantle – the D'' layer, apparently an accumulation of 'transpiration' products from the core – is conceived of being extremely complex and displaying strong lateral heterogeneity (e.g., Vidal and Benz, 1993; Kendall and Shearer, 1995), and ultra-low velocities in the D'' zone have continuously been reported (Li et al., 2017; Pachhal et al., 2022; Wolf et al., 2024). Furthermore, Wolf et al. conclude that chemically diverse D'' sections tend to plume upward to oceanic regions and to the Himalayas, and seismic anisotropy around these mantle columns is interpreted as products of rising fluids. A close link between upstanding/rising parts of the irregular D'' layer and oceanic basins was already indicated in the tomography study of Morelli and Dziewonski (1987). With regard to the energy driving Earth degassing processes, extraterrestrial relations may be more important than traditionally assumed (Gregori, 2001,2002).

As diapiric degassing columns cut through the mantle – entraining solid matter as well as giving rise to chemical reactions *en route* (cf. Hunt et al., 1992) – it can be expected that the mantle would show lateral variations in composition, anisotropy, and seismic wave-velocity. Thus, many studies have arrived at a clear overall picture for the upper mantle: relatively fast velocities for continental lithosphere keels and correspondingly slow velocities for oceanic mantle units – underlining the, by now, well-accepted concept of deep *continental roots* (e.g., Jordan,

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1975; Dziewonski and Woodhouse, 1987; Ritsema et al., 2004; Yuan and Romanowicz, 2010 and references therein). However, plate tectonics-inspired speculation about the thick cratonic roots has been persistent (e.g., Pearson et al., 2021; Yoshida and Yoshizawa, 2021), and even after decades of theorizing, there is seemingly no light at the end of the tunnel. Authors wonder why thick cratonic roots have resisted progressive entrainment into the mantle by convection (Yuan and Romanowicz, 2010). But the answer to such speculation is quite simple: The problem does not exist, because there is no real evidence that neither plate tectonic processes nor mantle convection have ever been in action. Outgassing from the core, in terms of rising fluid columns, has apparently built-up todays columnar-like lithosphere – with continental mantle roots and oceanic anti-roots.

The divergent lithospheric blocks (oceanic vs continental) have apparently developed by rising fluids with variable chemical composition. As such differences appears to vary along the D" layer (at the core-mantle interface), the individual ascending liquids (carbides, silicide, hydrocarbons etc) are likely to have undergone chemical reactions with heat production *en route* (cf. Hunt et al., 1992), giving rise to pockets of magma. Consequently, the primordial upper mantle and anorthosite-diorite crustal composition (Storetvedt, 2003/23) have been subjected to greatly varying physical and chemical alterations – building up the columnar-like lithosphere. The outcome is the low-velocity oceanic lithosphere with its thin deep-sea crust, primarily developed as late as the Upper Mesozoic (see below), and the much less-affected higher-velocity continental lithosphere. In other words, the continents are anchored to their respective 500+ km deep mantle roots, which for energetic and other reasons would make lateral continental drift an unlikely process. The remaining continental crust – i.e., that part of the originally thick pan-global surface layer that has not undergone significant sub-crustal delamination and oceanization processes, became extensively granitized during the Precambrian (cf. Storetvedt and Michaelsen, 2024 and references therein).

In a degassing Earth, a certain outward hydrostatic pressure will counteract the inward gravitational force, whereupon fractures in crust and mantle will be kept open. The exponentially increasing fractures with depth, as observed in deep continental boreholes (Kola and KTB, Germany) along with an unexpected amount of circulating hydrous fluids (Smithson et al. 2000), are important evidence in favour of a persistently degassing Earth. In addition, the internal rearrangement of its mass has given rise to changes in the planet's moments of inertia – i.e., changes of spin rate and spatial adaptation/true polar wander (Storetvedt, 2003/23 and references therein). It is these episodic changes in Earth's rotation that act as the hydraulic pumping mechanism for fluids – from the interior to the surface. For dynamical reasons, the spatial adjustment of a rotating planetary body (despite possessing a certain stabilizing equatorial bulge), will be in terms of intermittent dynamo-tectonic events. Again, it is the changes in planetary rotation that represent the mechanisms behind the pulsating Earth with its episodic inertia-driven crustal wrench tectonics. Rising magmas/gases are associated with tectonic vortex (Meyerhoff et al., 1996), i.e. wrenching tectonics! This physical principle also becomes a natural explanation of the hitherto unexplained episodic geological time scale. The relatively short-lived geological time boundaries correspond to the dynamo-tectonic upheavals constituting a combination of degassing-associated magmatic, tectonic, environmental events, and biological catastrophes – the latter caused by a combination of environmental changes and emission of toxic gasses. In studies of mantle and crustal processes, the role of supercritical fluids is gaining increasing attention (Liebscher, 2010; Galli and Pan, 2013; Pan et al., 2013; Thomas et al., 2023; Wang et al., 2021; Zeng, 2010). According to the degassing model, hydrous and other fluids will be in their reactive supercritical state, which expectedly is common even in the upper crust.

During the developing oceanic regions, both mantle and crust will have been permeated by rising fluids, transporting solid particles as well as giving rise to chemical reactions. Therefore, the developing oceanic mantle will have undergone a variety of chemical reactions endowed with latent heat, and production of related magma pockets. Thence, the oceanic mantle would be characterized by abundant chemical and isotopic anomalies, predictions that are consistent with the observed widespread chemical heterogeneity of oceanic basalts (Lambart et al., 2019 and references therein). The continental crust has apparently been much less effected by the combined hydrous-fluid-triggering eclogitization/delamination processes than the developing oceanic crust (cf. Storetvedt, 2003/23).

It is assumed therefore that the volatile pressure in the upper mantle beneath the continents has had a gas and liquid composition that has been different from that beneath the developing ocean basins. In accordance with this argument, Liu et al. (2016) – studying a large set of zinc stable isotopes in Upper Cretaceous continental basalts of eastern China, found that the regional mantle was carbonated – not hydrated as expected beneath developing oceans (Storetvedt, 2003/23). The findings of Liu et al. are important because they indicate that components such as silicon-carbide (SiC) and hydrocarbons may have been in abundance in the rising mantle flow beneath eastern Asia. For example, the unusually broad metalliferous belt across Central Asia may have been closely related to hydrocarbon compounds for leaching, transport and unloading processes. Thus, Gold (1999) emphasized that many metals are carried in hydrocarbons that have entered molecular arrangements with metals to form complex organometallics.

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ISSN number; ISSN 2202-0039

Although Earth degassing beneath Central Asia has had a chemical composition not leading to significant crustal thinning, the penetration of high-pressured volatiles has had a wide variety of other effects – outlined in two recent papers in Mongolian Geoscientist (Michaelsen and Storetvedt, 2023; Storetvedt and Michaelsen, 2024). We do not need to look to the distant geological past to discover consequences of planetary outgassing, because sudden breakthroughs of high-pressure gas, in the form of earthquakes, occur frequently. The unusually dense, widespread, and partly very strong seismic activity in Mongolia, in the western region up to magnitude 8 on the Richter scale, plate tectonics has no explanation. If, however, one builds on the degassing theory, sudden yielding of rock strength after accumulation of high volatile pressures in the crust becomes a natural explanation (Michaelsen and Storetvedt, 2023).

The Earth consists of an interconnected system of episodic physical, chemical and geological phenomena. This means that the dynamic pulses that characterize the development of the world's ocean basins will in different ways also be reflected in continental surface events – by magmatic, tectonic, environmental, biotic processes, and ore emplacements. The time horizon to be considered in the present assay is the most crucial one in development of the modern crust – ranging from the late Carboniferous/early Permian to the Cretaceous/Tertiary boundary. This is also the period Alfred Wegener's hypothesis of continental drift is mainly about. Based on a mixture of dubious geological and palaeoclimatic arguments, he united the continents (Pangea), and this failing foundation the geosciences have so far been unable to get rid of. By this hypothetical amalgamation, the classical narrow and elongated intracontinental Tethys (**Fig. 1**) – extending from Southeast Asia, via the Middle East to the Mediterranean region (cf. Sonnenfeld, 1981 with references and contributions therein), and later with biogeographic extension across the pre-oceanic Central Atlantic to Central America (Hallam, 1977; Aubouin et al., 1977). Under the auspices of plate tectonics, however, the Tethys has become a wide western oceanic gap in Pangea that closed, reopened, and eventually closed again – allegedly subducting about 5,000 km of oceanic crust before the oceanic plate tectonic Tethys eventually disappeared. However, such a development pattern has, on biogeographic and palaeoclimatic grounds, been rejected (e.g. Dickins et al., 1993; Khan and Tewari, 2016). In the same direction, modern exploration of the world's oceans has given strong reasons to believe that prior to the Upper Mesozoic, a significant portion of today's deep-sea crust was still quasi-continental (see later). Therefore, the extension of the Mesozoic Tethys across the Central Atlantic (**Fig.1**) seems realistic.

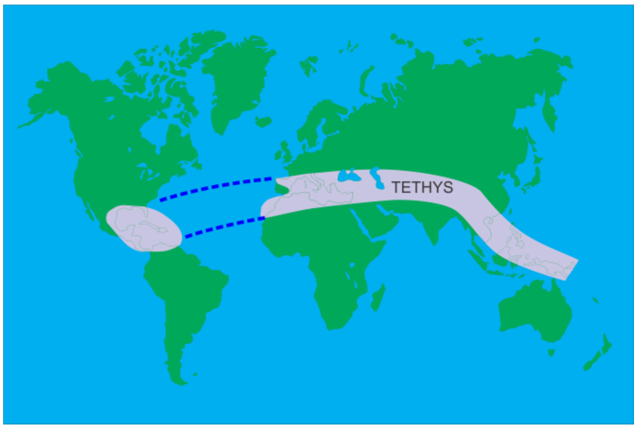

Fig. 1 Sketch map of the traditional Mesozoic Tethys – a narrow, elongated seaway on the southern flank of Eurasia, as it was perceived in pre-plate tectonic days. Until the late Cretaceous, deep ocean basins did not exist to any significant extent, so during most of the Mesozoic, the Central Atlantic was also an irregular, stagnant shallow-water region from which a greater number of deep-sea wells have found high concentrations of black organic-rich sediments. On biogeographic basis, Aubouin et al. (1977) and Hallam (1977) extended the Jurassic Tethys across the central Atlantic to Central America. The southern curvature of the Indonesian sector can be linked to the pronounced late Cretaceous-Tertiary counter-clockwise rotation of the Austral-Asian conjoint (Storetvedt, 2003/23), a movement which according to GPS measurements is still ongoing.

Despite today's abundant access to information that strongly rejects both the Gondwana concept and the rest of the continental drift hypothesis, these ideas continue as a matter of course. In the grip of plate tectonics and the 'Wilson Cycle', Wegener's fan-shaped Tethys has led Asia's geological history into a chaotic mix of continental tiles, plates and blocks, invented oceans and artificial subduction zones. Auxiliary explanations abound! However, in a general statement on today's fragmented tectonic history, van Andel (1985) described the situation as follows: "As plates and plate boundaries multiply, small platelets appear and disappear for little reason other than without them a postulated set of plate movements is not feasible. Reconstructions of plate history have become much more uncertain, diverse, and above all idiosyncratic."

The labyrinths of doctrine

"There is a popular misconception that science is an impersonal, dispassionate, and thoroughly objective enterprise. Whereas most other human activities are dominated by fashions, fads, and personalities, science is supposed to be constrained by agreed rules of procedure and rigorous tests. This is, of course, manifest nonsense. Science is a people-driven activity like all human endeavour, and just as subject to fashion and whim". This quotation, from the opening passage of Paul Davies' introduction to Nobel laureate Richard Feynman's *Six Easy Pieces* (Feynman, 1995), provides a precise description of the personified development of continental drift and its

ISSN number; ISSN 2202-0039

plate tectonics successor model which in 1968 was proclaimed the new geoscientific worldview. But even then, the artful picture was marred by dark clouds on the horizon.

In addition to nature's stubborn refusal to comply with the twin-concepts of seafloor spreading and subduction, many classical and important geological aspects of the continents have largely remained non-topics. For example, how can we explain the extensive shallow seaways that repeatedly existed across the continents in the geological past, and the fact that since the early Palaeozoic the present land masses have never been drier than now? And what is the cause of continental basins? Other pressing problems are the shifting geographical arrangement of tectonic belts, the great variability in crustal thickness, the cause of the episodic geological time scale, the origin of deep continental mantle roots, oceanic anti-roots, etc. Within plate tectonics thinking, all classical problems have remained in the dark. However, the Earth is a system of interconnected phenomena, so with a functional overarching theory, solution of one problem should automatically direct us to other phenomena as well as predicting unbiassed answers to new problems. Without a utilitarian maxi-theory, geoscientific understanding is like fumbling around in the dark. Without an overarching theory with continuous predicting capacity, data about Earth will end up in an increasingly larger stock of uncoordinated information. The present paper retrieves both new and old data and ideas from this databank and place them in a fresh theoretical context.

Palaeomagnetism and Wegener's hypothesis

After decades of almost collective prejudiced refutation by the geological community, palaeomagnetic studies in Cambridge and London in the 1950s brought Wegener's drift hypothesis out of obscurity. It is beyond doubt that it was Keith Runcorn (Cambridge, and from 1956 in Newcastle) who, primarily through his extensive international lecture tours, almost single-handedly gave renewed attention to continental drift. To explain between-continental discrepancies of paleomagnetic polar wander paths, it was difficult to avoid that some form of relative continental movement had occurred in recent geological times. A certain rivalry arose between Patrick Blackett's group at Imperial College (London), who studied the magnetization of the early Tertiary Deccan lava complex of India, and Keith Runcorn's team who worked on the North Atlantic continents. For the study of global tectonics, paleomagnetic research was a completely new geophysical discipline, which in competition with the established and higher ranked natural sciences, was badly in need of publicity. Nothing would serve the subject better than if it could present new physical evidence that the geological community's long dismissal of Wegener's hypothesis had been wrong. In a retrospective glance on the prevailing climate of opinion in geophysics, prior to the entry of palaeomagnetism, Runcorn (1981) wrote: "It was appreciated that Wegener's theory had created lively debate, but it was regarded as merely one of a few youthful indiscretions best forgotten as geophysics was rapidly emerging into a mature subject. Geophysicists were very conscious that their subject was overshadowed by modern physics with its great achievements and prestige".

It was precisely this deplorable situation the British palaeomagnetists wanted to do something about, and which started a new struggle for hegemony. Although they were without real insight in geology and paleoclimate, subjects on which Wegener's reconstructions allegedly rested, and though the palaeomagnetic polar estimates were of highly variable quality, they were convinced, even from the early beginning, of being on their way to revolutionizing the geological sciences. The intentions were the best, but the professional basis, apart from classical experimental physics, were nearly completely missing. Despite the estrangement in geological knowledge of crucial interpretive importance, everything came to revolve around Wegener's model. Nevertheless, hardly anyone had consulted his book, or even seen it, until it was reprinted in 1966. In a private conversation with present author in 2003, Kenneth Creer, one of the leading palaeomagnetists in the Runcorn group at the time, admitted how intense and busy the working situation had been – making the following revealing statement: "We didn't have time to look for that old book in the library". Runcorn's closest research assistant at the time, David Collinson, also acknowledged how hard-pressed the situation had been. This busyness was rooted in two conditions: 1) competition with the Imperial College group and 2) the race to be the first group in the world to present conclusive evidence in favour of Wegener's continental drift – with the intention of revolutionizing the Earth sciences.

Wegener's classic Pangaea, in which the individual continents had split and supposedly drifted apart since early Mesozoic time, was taken from sympathetic secondary literature – primarily from Holmes (1944) where the last chapter of his popular textbook *Principles of Physical Geology* was devoted to continental drift. Arthur Holmes had published extensively on radioactivity and age of the Earth, and in 1929 followed an article on mantle convection as a possible driver of continental drift (Holmes, 1929). The last diagram in his book demonstrated the suggested convective machinery. To the palaeomagnetic groups in London and Cambridge/Newcastle this positive attitude to Wegener's work must have been very welcome. The traditional opposition to the drift hypothesis had basically been that it lacked an acceptable driving mechanism. But Arthur Holmes, one of the leading geological theorists at the time, had pointed to a possible way out of this dilemma. Already from the mid-1950s onwards, the Runcorn group favoured lateral separation of the North Atlantic continents. From his palaeomagnetic database, Runcorn (1956) suggested a systematic continental displacement, of about 25-30° of longitude, based on the North Atlantic polar curves, and Creer et al. (1957) alluded to the possibility that their separation had not been completed by mid-Mesozoic time. From now on, the question of lateral crustal mobility

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ISSN number; ISSN 2202-0039

was gaining impetus as an integral part of palaeomagnetic research.

The Imperial College group (Clegg et al., 1956, 1957; Deutsch, 1958; Deutsch et al., 1958) appeared to have gained an advantage in the competition between the two groups. They had apparently confirmed India's large-scale northward drift, prior to the alleged collision with Asia in the early Tertiary. Wegener (1929/66) had argued that “It is assumed in our reconstruction that the west coast of India was joined to the east coast of Madagascar”. The question is therefore whether the London group really had presented independent geophysical evidence in favour of India's large-scale northward drift. It would later come to a day that the group was aware that there were two obvious tectonic alternatives for the Deccan palaeomagnetic axis: 1) India had either undergone large-scale northward migration, including some rotation, or 2) a tectonic rotation *in situ*. Their choice had fallen on the first alternative, but it was later revealed that the favoured interpretation was purely political. As physicists, they were unable to evaluate the geological and palaeoclimate arguments of Alfred Wegener and Alexander du Toit, so they blindly accepted their conclusions. Thus, a combination of professional alienation, socio-political factors, and competition with the Runcorn group had settled the question (see Storetvedt, 2023, p. 69-73). Nevertheless, Wegener’s practically dis-banded drift scheme had apparently become imbued with life and vitality. No one bothered to consider the possibility that the divergent paleomagnetic polar wander curves could be united in a far less mobile tectono-physical system.

In the late 50s and early 60s, a stream of publications associating palaeomagnetic polar wandering paths to Wegenerian drift, at the time when three symposia on the same topic were arranged, conveyed the impression of a promising and rapidly progressing line of research (Le Grand, 1988). But problems were lurking in the background. It had been found that at least some of the land masses had been subjected to *in situ* rotation. Thus, even with their proposed large-scale northward translation of India, the Imperial College group had to include a certain rotation of the subcontinent, while palaeomagnetic studies in Japan had proposed a tectonic bending of the Archipelago (Kawai et al., 1961). But above all, it had been found that Australia had undergone substantial counterclockwise rotation (Irving, 1957, 1958, 1964) – a characteristic inertia-based motion in the southern hemisphere, but which did not capture the interest at the time. Confirming Wegener’s Pangaea, by matching poorly established polar wander curves, was in the forefront of attention though this turned out to be a speculative and difficult affair (cf. Creer, 1970).

The first serious palaeomagnetic hint that Wegener's lateral motions might be wrong, and that an alternative mobilist model was needed, arose from Jean Louis Roy’s juxtaposition of the North Atlantic continents along with their polar migration curves (Roy, 1972). Roy showed that even for the relatively parallel polar tracks of Europe and North America – considered as graph evidence of lateral continental drift at the time – had an inherent problem. When Roy closed the North Atlantic, there was a mismatch between age-determined pole positions – North American poles were systematically shifted south of the European ones by 15-20°. It would take almost 20 years before this problem found an adequate solution (Storetvedt, 1990): The North Atlantic continents had had about the same separation as today, but by the end of the Cretaceous, the North American crust (or most likely only its upper part) had undergone ca. 25° south-westerly 'in situ' rotation relative to Europe. Thus, had both the E–W separation of the North Atlantic polar curves as well as the perturbing southward displacement of the North American one become products of a moderate inertia-driven south-westerly rotation of North America (**Fig. 2**).

Fig. 2 Palaeogeographic model to account for a) the observed separation in longitude of the North Atlantic polar curves, and b) the southward latitudinal shift of North American poles compared to corresponding European ones. Only c. 30 degrees of SW clockwise rotation of North America relative to Europe – with the Euler pole in NW Canada, with continental movement from position 1 to position 2 and slipping across the NE Pacific Benioff zone, is sufficient to explain the paleomagnetic discrepancies between the two continents. No between-continents lateral motion is required, and all classic fitting problems disappear. From Storetvedt (2003/23).

That is, the North Atlantic polar discrepancies could be accounted for by a moderate inertia rotation (clockwise) of North America without invoking lateral continental drift. This mobile stage occurred during the Alpine climax, after planetary degassing and related processes had formed the thin and mechanically weaker deep-sea crust. At the same time, high-pressure volatiles penetrated the fractures of the continental crust, creating horizontal planes of weakness.

In this explanation, the western North American margin should, as expected, define a tectonic front – with obduction along the relatively shallow inclined Benioff Zone of the Western Pacific. Consistent with this prediction, seismic reflection imaging beneath southern Vancouver Island (south-western Canada) displays weakly-inclined horizons

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in the upper crust (Green et al.1986), which can be interpreted as moderate upward movement of detached crustal slivers in the direction of the Pacific. As the upper reflecting horizon outcrops in the Leech River Fault, suggest that the obducted crust is ruptured by sub-horizontal shear zones (**Fig. 3**), an observation that is consistent with the crustal 'deck of cards' model (Michaelsen and Storetvedt, 2023). Thus, along the Pacific margin, the upper North American crust apparently had been split into sub-horizontal flakes subjected to the oblique south-westerly pressure – that is, the tectonic effect would increase southwards and expectedly diminish downwards. However, inertia forces are weak forces, so without conditions that have greatly reduced crustal rigidity, at least along reflecting horizons, inertial forces would by themselves be completely insufficient for thrust plane partitioning. But for an Earth in a state of progressive degassing, the tectonic power requirement will have a ready solution.

Deep continental drillings (Kola and TKB, Germany) have shown that fractures open exponentially with depth, and that even at relatively shallow depths the crust is permeated by hydrous fluids (e.g., Smithson, 2000). The reactive aqueous fluids will most easily infiltrate the orthogonal fracture system. But inertia-driven wrenching will simultaneously break up horizontal fracture zones which, together with the reactive fluids, will serve as seismic reflective horizons. The supercritical state of liquids can apparently break down solid rocks into mud which presumably is another effective lubricant in wrench tectonics processes. In support of the assumption of supercritical fluids being able to decompose solid rocks, many mud volcanoes occur in both continental and oceanic settings around the world. Furthermore, the presence of aqueous fluids will easily produce serpentine which can contribute to the formation of smooth rock horizons. Such lubrication processes are probably crucial factors for the two tectonic rotations uncovered in Central and South Mongolia (Michaelsen and Storetvedt, 2023; Storetvedt and Michaelsen, 2024).

The disrupted marginal front of south-western Canada probably also affected the shallow eastward-dipping tectonic plane defined by Taber and Smith (1985). The south-westerly clockwise torsion of North America most likely involved only the upper crust thus detaching it from the deeper parts of the Circum-Pacific Benioff Zone (Benioff, 1949, 1954). Due to the south-westward shift of the upper North American crust, the deeper Benioff plane was shifted hundreds of km inland (increasing southwards) – which may explain why the Rockies and the Cascadian Range of western North America occur much further inland than the corresponding Andean Range of South America (see below). Moreover, owing to the southwestern swing of the upper crust of North America, the western part of the continent will sit above the moderately inclined Benioff Zone of the NE Pacific. Consequently, degassing from the core and mantle rising along the Benioff plane continues vertically in the tectonically reactivated upper crust. Thus, hydrocarbons, salt and leached metal concentrations form a coast-parallel inland belt that is the most productive in all North America. Along this belt of degassing-related surface products, there are also a string of craters (including Chicxulub in southern Mexico) – dating from the time of North America's southwestern rotation **(Fig. 2**). This means that craters are blow-out structures – NOT impacts (see Fig. 17 in Storetvedt and Longhinos, 2012).

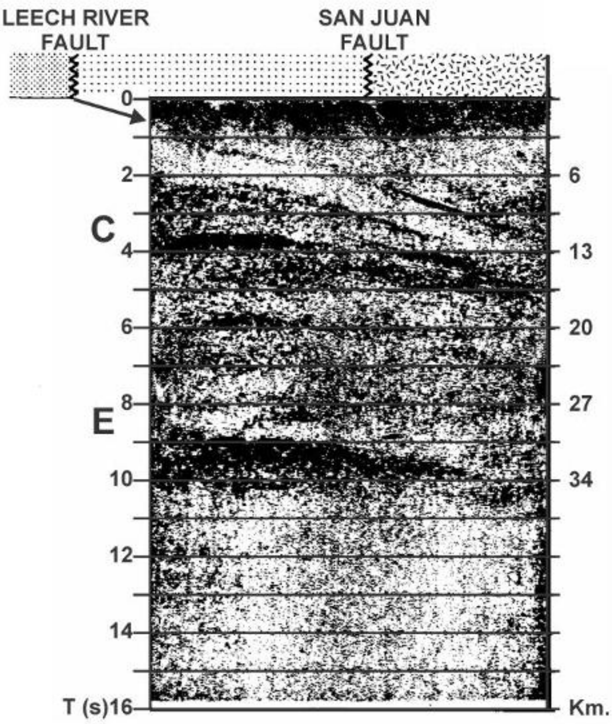

Fig. 3 Unmigrated seismic section below southern Vancouver Island – after Green et al. (1986). As a consequence of clockwise rotation of North America (Fig. 2), note how the upper 30 km of the regional US Pacific crust has been slightly obducted and split into sub-horizontal thrust planes.

Wrench tectonics and the late Cretaceous Atlantic

In the investigation of Storetvedt (1990), it emerged that during the Upper Cretaceous-Lower Tertiary both Eurasia and North America belonged to the northern palaeo-hemisphere. The corresponding palaeoequator ran along the southern Mediterranean, with its western continuation across Central Atlantic towards southern Central America, and with eastern extension across the Middle East and the Indonesian archipelago (see also below). With their geographic positions north of the Alpine palaeoequator – after the North Atlantic crust, apart from major parts of the Shetland-Faeroe-Iceland-Greenland continental ridge, had subsided to become a thinned and mechanically weak deep-sea domain. Both Eurasia and North America underwent

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independent clockwise wrench rotations *in situ* – turning the northern Atlantic region (including the thick-crusted Iceland) into a left-lateral shear zone. In this global tectonic unrest, North America underwent a stronger clockwise inertial swing of ~30° relative Europe giving rise to the present-day south facing fan shape of the North Atlantic (cf. **Fig. 2**).

Wrench tectonics is an inertia-based, latitude-dependent system where the higher standing continental crust will be most strongly affected. Therefore, the upper crust of North America would have been subjected to stronger inertia drag relative to the surrounding Central Atlantic and NE Pacific crusts. As a result, both sets of the fundamental orthogonal fracture system of the adjacent oceanic crusts – which prior to the moderate reorientation of North America were directed NNE and WNW respectively – were reactivated. In this way, the mega-scale fracture zones in the Central Atlantic – i.e., the WNW set (Kane, Atlantic, Oceanographer etc.), and the corresponding fracture set in the North-East Pacific (Mendocino, Murray, Clarion etc.) became transcurrent shear zones. Thus, in this explanation the seafloor spreading related transform fault concept of Tuzo Wilson (1965) becomes non-relevant.

In response to the accelerating development of the thin and mechanically weakened deep-sea crust during the late Mesozoic (see also later), the equivalent upper crustal cap of the continents of the southern palaeo-hemisphere was subjected to inertia-driven counterclockwise wrenching – turning the corresponding palaeoequatorial zone into an overall transpressive belt – i.e., the Alpine belt proper. During this global tectonic cataclysm, the essential part of global crustal mobility (mostly moderate) took place – giving rise to between-continent palaeomagnetic polar discrepancies, shear deformation, accentuated mineralogical alteration along prevailing tectonic grains (sometimes including both orthogonal fracture sets), regionally developed linear marine magnetic field anomalies etc. (see below). But it still took approx. 100 million years before mountain ranges and epeirogenic continental uplifts took place (Storetvedt, 2003/23, 2015).

After the late Mesozoic to early Tertiary global wrench tectonic revolution, the non-oceanized (remaining) smaller landmasses, Australia and Antarctica, were surrounded by thin and mechanically weak oceanic crust. Hence, these continents have undergone much stronger wrench rotations than the major continents. Modern GPS velocity vectors show that in both cases the same motion pattern, as of ca. 100 million years ago, is still being maintained. A most noticeable effect of the relative continental rotation/interaction is that both the North and South Atlantic acquired their present southward fanning-out configuration. But before the late Cretaceous wrench rotations, the opposing continental margins of the Atlantic were more parallel than now (cf. Storetvedt, 1990; 2023, p. 209-220). By then, most of the remaining traditional 'land bridges' had been broken up, strongly assimilated by upper mantle processes with subsequent isostatic subsidence. **Fig. 4** displays the original (pre-Upper Cretaceous) configuration of the Atlantic continents along with indications of subsequent upper crustal wrench rotations (curved arrows) as well as a sketch of reactivated transverse fracture zones of the equatorial Atlantic.

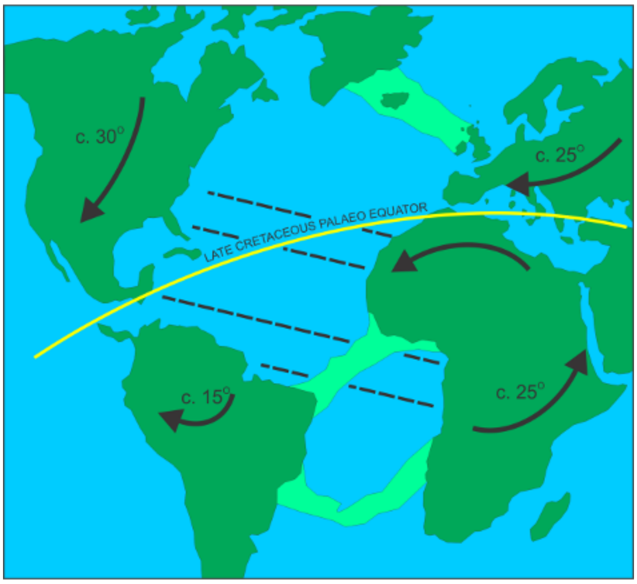

Fig. 4 Configuration of the Atlantic Ocean during early stages of Upper Cretaceous deep-sea development with subsequent inertia-based wrench rotations (curved arrows) of adjacent continents – relative to the corresponding palaeoequator (Storetvedt, 2003/23). Note the parallelism of opposing continents. A few former land connections are marked in light green. In the North and South Atlantic, the opposing continental margins, prior to their relative rotations, follow reactivated NNE segments of the basic right-angled fracture network. Reactivated elements of the orthogonal WNW-oriented set – a dominant feature in the equatorial and western Central Atlantic are sketched out by dashed lines. See text for details.

Owing to the relatively narrow equatorial passage between North Brazil and equatorial West Africa, the intervening Atlantic underwent unusually strong tectonic squeezing. Thus, both the Gulf of Guinea, the northeastern margin of Brazil and the intervening oceanic crust show many signs of strong tectonic forces. For example, ODP Leg 159, drilling adjacent to the ocean-continent transition off the Ivory Coast-Ghana, uncovered intense folding, faulting, and shear deformation in the Cretaceous strata (Mascle et al., 1995). The fact that the basement of the highly fractured North Brazilian Ridge – NBR, (Hays and Ewing, 1970) is 1-2 km deeper on the landward side than on the seaward side (Bryan et al., 1973) concur with a compressive-transpressive origin of NBR. Also, an unusually dense system of trans-oceanic shear zones, belonging to the WNW set of the pan-global orthogonal fracture system, characterizes the equatorial segment of the Atlantic, partly cutting into the bordering continents. In this context, the Romanche Fracture (RFZ) is, over a length of 500 km, capped by carbonate banks formed when these summits were close to or above sea level. Sampling on one of these seamounts uncovered c. 5 My old reef limestones (Bonatti et al., 1977; Bonatti and Chermak, 1981). These data suggest that the RFZ and probably the rest of the equatorial Atlantic, was subjected to substantial late Miocene-early Pliocene vertical tectonic uplift, and the subsidence rate since the limestones were deposited has been nearly an order of magnitude faster than theoretical expectation based on the seafloor spreading model (Bonatti and Chermak, 1981).

Early studies of sediment distribution on the crest and upper flank of mid-ocean ridges (Ewing et al., 1966; Ewing and Ewing, 1967; van Andel and Bowin, 1968) indicated that the uplift of these ridges is only a few million years old. As originally suggested by van Andel and Bowin – and later substantiated by Storetvedt (2003/23; 2015) and Michaelsen and Storetvedt (2023, and references therein), the young uplift of the mid-ocean ridges occurred concurrently with the late Miocene origin of continental mountain ranges. This is just a smaller isolated example of how convincingly simple Earth's history really is – once its actual working system has been discovered. The most important thing in science is to create unity from a multiplicity of disorganized information. Therefore, the Earth's degassing-based pulse-like modus operandi apparently represents the long-awaited coherent dynamo-tectonic system; salient aspects of its geological development and surface products appear to form an integrated whole. The Upper Cretaceous transpressive force along the North Brazilian margin (caused by Africa's counterclockwise rotation, cf. **Fig. 4**) brought the South American crust (probably primarily its outer layering) into a moderate clockwise torsion, counteracting the counterclockwise inertial motion of the southern palaeo-hemisphere. The resultant motion of the South American upper crustal layer is a c. 15°clockwise swing – a motion that led to left-lateral shearing along the Motagua Fault Zone of southern Mexico with further extension across the northern Caribbean, before ending in a tectonic front along the Lesser Antilles Arc. The sinistral motion between North and South America – originally based on palaeomagnetic data (Storetvedt, 1990, 1997, 2003/23), is supported by GPS velocity vectors from Venezuela and the Caribbean (Dixon et al., 1998; Pérez et al., 2001).

According to the idea that continental wrenching resembles the behaviour of a deck of cards being obliquely affected by external forces (Michaelsen and Storetvedt, 2023), in addition to the likelihood that South America has been subjected by two oppositely directed forces (Storetvedt, 1997, 2003/23), it is likely that the upper South American crust has undergone internal tectonic deformation. In this context, there is a distinct change in structural trend of the Central Andes, between 10°S and 30°S, which has led to speculation about bending of South America – named Bolivian Orocline by Carey (1955). Palaeomagnetic studies have substantiated this suggestion (Heki et al., 1983; Kono et al., 1985; Roperch and Carlier, 1992). From an evaluation of existing palaeomagnetic data, Roperch and Carlier suggested that the orocline bending was of late Mesozoic-early Tertiary age. The slightly curved N-S oriented Pantanal Basin, between Bolivia, Brazil and Paraguay, is a tectonically active inlier depression with numerous faults and a reduced crustal thickness of up to 10 km compared to the surrounding crust (Rivadeneyra-Vera et al., 2019). Due to lack of data, the origin of the depression is uncertain, but it is likely that it dates from the global tectonic climax that took place in the late Cretaceous to early Tertiary – seemingly directly related to the crustal ruptures associated with formation of the Bolivian Orocline. Therefore, the combined tectonic and inertia forces affecting South America at that time (**Fig. 4**), reactivated primordial zones of crustal weakness – enforcing intracontinental structural reactivation, fluid-triggered crustal thinning, and isostatic subsidence of the Pantanal Basin.

In an Earth degassing scenario, the lower crust would have experienced a progressive buildup of a confining pressure caused by rising volatiles. Thus, the outward-directed hydrostatic pressure would have counteracted the inward gravitational pressure – thereby creating a pressure bath situation which is the likely cause of the exponential increase in fracture volume with depth, revealed in deep continental boreholes (Kola and KTB, Germany). The presence of abundant aqueous fluids in these drilling sites was another completely unexpected discovery. These unforeseen findings give rise to better understanding of the transition from continental to deep-sea crust ('crustal oceanization'). Thus, the sharp natural occurrences of granulite to eclogite transition have demonstrated that the process is strongly impeded by the absence of hydrous fluids (e.g., Austrheim, 1987, 1998; Leech, 2001; Kaatz et al., 2021 and references therein). Thus, Austrheim (1998) argued that hydrous fluids are much more critical than either temperature or pressure. In the same vein, Leech (2001) concluded that to drive the eclogitization process, with progressive gravity-driven sub-crustal delamination of the granulitic crust, aqueous fluids is seemingly much more important than temperature and pressure. However, in a degassing Earth, the lower to middle crust may have been subjected to both heat generation by chemical reactions as well as strong confined hydrostatic pressure – thus satisfying the physical conditions of supercritical fluids.

A prominent example of significant loss of eclogitized crust to the upper mantle was revealed by the ECORS deep-seismic reflection profile across the Parentis Basin, inner Bay of Biscay (Pinet et al., 1987). The authors linked the loss of the entire lower crust to granulite-eclogite phase transformation, and the density of eclogite will easily be

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higher than the density of the surrounding upper mantle. As a result, it becomes gravitationally unstable, disconnects and sinks into the upper mantle. For a relatively narrow ocean such as the Atlantic, deep-sea subsidence can easily cause prominent fracture zones to form parallel opposing margins. Furthermore, accelerated eclogitization with resulting crustal delamination along the fault-related margins would have led to expected bands with associated thick sedimentary layers – on the seaward side of many margins. In this process, the eclogitized upper mantle-lower crustal level also comes closer to the surface, which in turn leads to marked positive (induced) gravity anomalies along many continental margins. The combination of abnormally thick sedimentary belts and unexpected positive gravity anomalies has remained enigmatic observations, but not so within the degassing-driven wrench tectonics theory. As demonstrated in **Fig. 5**, the Atlantic margin of North America, including the Caribbean, stands out with an anomalously thick sedimentary collar (up to 20.000 m). The reason for these unexpected thick deposits can be associated with the counterclockwise rotation of North America in the late Cretaceous-early Tertiary (**Fig. 2**). This movement led to transtensive conditions along its eastern seaboard – resulting in increasing fluid infiltration, eclogitization, gravity-driven crustal delamination, and isostatic basin formation that increased southward (from Newfoundland to the Mexican Gulf).

As shown in **Fig. 4,** the Upper Cretaceous saw the beginning of Africa's independent counterclockwise inertial rotation – at the same time as the surrounding oceanic crust was undergoing progressive distortion. It was thus inevitable that the thinner deep-sea crust was subjected to wrench deformation due to Africa's motion. **Fig. 6** demonstrates the wrench tectonic arrangement of the southwestern Indian Ocean – based NOAA ETOPO1. Note how the arcuate, mostly SSW-NNE oriented, deep-sea fault pattern is in accordance with Africa's rotation. The arcuate structure represents a 'link-chain' system that will occur whenever wrench deformation of thin oceanic crust superimposes the pan-global orthogonal fracture network. Also, thick continental crust, like that of Central Asia, have experienced similar structural bending – but this is probably only an upper crustal structural development. Nevertheless, the south-facing tectono-topographic shape of Mongolia is a characteristic example of this inertia-driven structural form (Michaelsen and Storetvedt, 2023).

The initial discovery of deep-sea tectonic shearing

The findings of linear magnetic field anomalies off the west coast of North America (Mason, 1958; Mason and Raff, 1961; Raff and Mason, 1961) ushered in a whole new era in sea-floor exploration. The substantially flat and heavily sedimented deep sea region was identified by relatively narrow linear bands of positive and negative field anomalies. The linear field pattern, with amplitudes ranging to the order of 500 nanotesla, dominated the whole deep-sea plane. Another surprising observation was that the N-S oriented magnetic pattern was markedly disturbed by major E-W and transverse fault zones as shown in **Fig 7**.

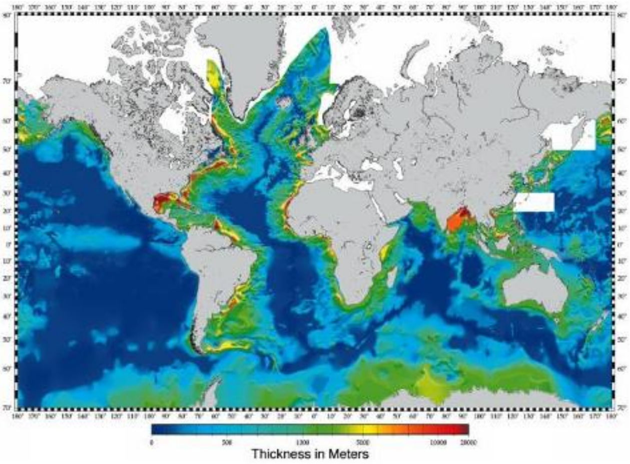

Fig. 5 Distribution of total sediment thicknesses of the world's oceans and marginal seas compiled by NGDC, Marine Geology & Geophysics Division.
http://www.ngdc.gov/mgg/sedthick/sedthick.html Note how the Atlantic margins have by far the thickest sedimentary layers. These large accumulations are directly related to regional transtensive conditions, with associated crustal thinning and isostatic subsidence, which occurred during moderate late Mesozoic continental wrench rotations (Fig. 4).

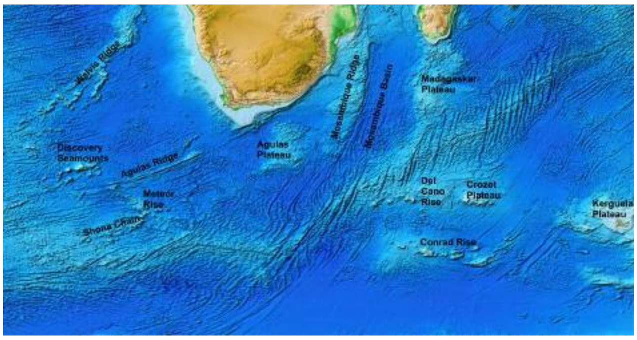

Fig. 6 The tectonic morphology of the southern Indian Ocean, with partially assimilated continental fragments (plateaus and ridges) and the pervasive arc form caused by Africa's counterclockwise torsion (Fig. 4). From NOAA ETOPO 1.

By attempted fitting of the magnetic anomaly pattern across the faults, the accumulated displacement figure was estimated to be up to 1400 km (Raff and Mason, 1961; Vacquier et al., 1961). This was the first and surprising evidence that even the thin deep-sea crust had undergone structural deformation. It was concluded that the supposed two-dimensional anomaly source lay at a relatively shallow depth in the crystalline basement. Various possibilities were

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suggested, including 1) variations in topography of the magnetic source layer and 2) contrasts in magnetic susceptibility – in both cases the fluctuating anomalies were ascribed to variable magnetization induced by the ambient geomagnetic field. Moreover, Mason (1958) suggested that the prevailing "north-south lineation of the anomalies and the right lateral displacement along the San Andreas fault, may well be related by a single structural hypothesis, possibly connected with a westerly movement of the North American continent relative to the floor of the Pacific". Mason's regional tectonic proposal concurs with the wrench tectonic (GWT) linkage developed 3 decades later (Storetvedt, 1990), as well as explaining various structural aspects discussed above (and below).

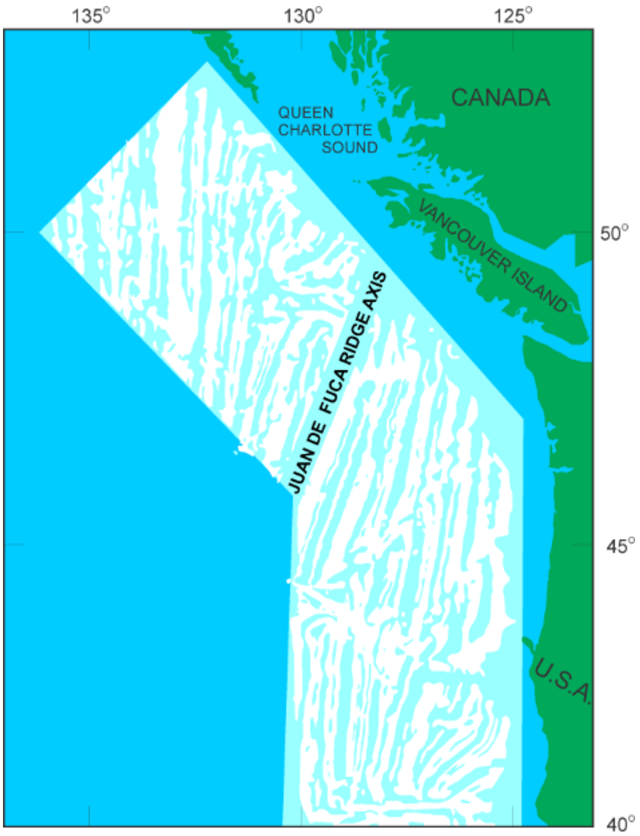

Fig. 7 Magnetic field anomalies off western North America – based on Raff and Mason (1961). Positive/negative anomalies are shown in pink/light green.

In GWT, the marine magnetic linearity are products of contrasts in magnetic susceptibility produced by shear tectonic mineral alteration. Consequently, undulating induced magnetic field anomalies occur perpendicular to the prevailing shear grain. But in the Central Atlantic in particular, both sets of the fundamental orthogonal fracture network have undergone wrench reactivation with associated mineral alteration and magnetic susceptibility contrasts. Therefore, in larger areas of the Central Atlantic, notably in its western half (associated with the westward wrenching of North America), displays an orthogonal anomaly network. The World Digital Magnetic Anomaly Map (EMAG 3) confirms this prediction (**Fig. 8**). Thus, in a larger part of the western Central Atlantic the magnetic anomalies form an orthogonal network in accordance with shear reactivation of the underlying right-angled fracture system. These shear-related anomalies, basically formed during the global dynamo-tectonic climax in Upper Cretaceous-Lower Tertiary, was associated with the origination of the thin and mechanically weak deep-sea crust. The stronger inertial drag of the continental blocks gave rise to tectonic shear reactivation of surrounding thin seafloor crust. This is the reason why marine magnetic field anomalies mainly occur along the relatively narrow Atlantic, and in near-continental shear belts in The Indian and Pacific oceans.

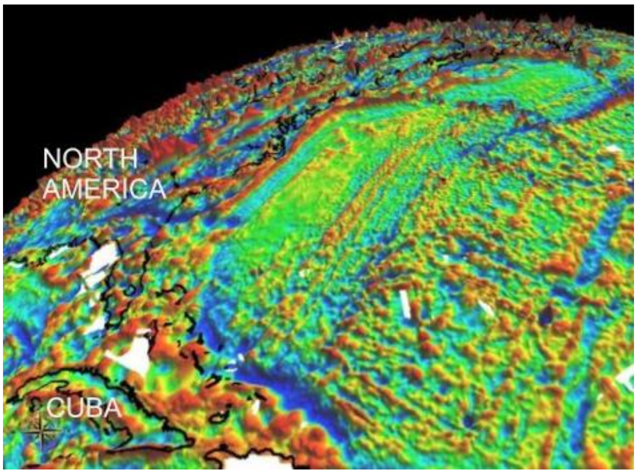

Fig. 8 Cut from World Digital Magnetic Anomaly Map (EMAG 3). To a major extent, the anomalies depict an orthogonal network for which the individual segments correspond to the orientation of the underlying basement fracture system with NNE and WNW orientation respectively.

For a realistic assessment of the linear marine magnetic field anomalies in the NE Pacific, by Mason and colleagues, information on rock composition of the crystalline basement was still very scanty. The magnetic sources had to lie beneath the striped field pattern, and the sharpness of individual anomalies suggested that they originated from a shallow depth in the crystalline basement. Positive anomaly bands were related to relatively strong magnetic susceptibility (and therefore elevated magnetic induction), while negative belts were associated with lower magnetic susceptibility. However, time was not ripe for Mason's proposal. In contrast, Vine and Matthews (1963) advanced an alternative explanation that seemed to fit with the recently launched seafloor spreading model (Dietz, 1961; Hess, 1962). The proposed spreading model was operating along mid-ocean ridges, which supposedly marked the upwelling limbs of hot convective cells in the mantle. Suddenly, the demonstration of tectonic deformation of the deep-sea crust, as revealed by the NE Pacific Magnetic surveys, had been forgotten – or perhaps not even noticed by the majority.

Marine magnetic anomalies enter the drift debate

Vine and Matthews associated positive/negative marine magnetic field anomalies with corresponding normal/reverse geomagnetic polarity. This proposal predicted that the magnetic anomalies were symmetrical about the 'mid-ocean' ridges, which, according to the spreading model, meant that the linear anomaly system was a kind of tape recorder of polarity changes of Earth's magnetic field. So, if the polarity history could be dated, the geosciences would have an effective method for dating the development of the deep-sea crust. A polarity-time scale was soon established for the past 3-4 million years (Cox et al., 1967) – a pattern allegedly confirmed by palaeomagnetic measurements on core sections of deep-sea sediments (Opdyke et al., 1966). The Vine-Matthews model came at a time when the revival of Wegener's continental drift was in accelerating progress, and thus the new model triggered a comprehensive magnetic field surveying of the world oceans. For a few years, the literature was replete with reports of alleged correlation of marine magnetic anomaly profiles over distances up to thousands of kilometres (e.g., Vine and Wilson, 1965; Vine, 1966; Heirtzler et al., 1966; Heirtzler et al., 1968; Pitman et al. 1968; Dickson et al., 1968; Le Pichon and Heirtzler, 1968). For world-wide correlation, an anomaly numbering system (with increasing numbers from 1 at mid-ocean ridges to 34 near the quiet zone along continental margins) was erected. Once accepted, a massive research effort ensued to refine and 'confirm' the validity of the established age isochrons of sea floor spreading which by then had become a matter of course.

After the mechanism of seafloor mechanism became entrenched, alternatives to the Vine-Matthews model were disregarded and soon abandoned. Contrasts in magnetic susceptibility (Mason, 1958) and rock alteration as sources of the linear anomalies were frequently discussed in the first decade after their discovery (Drake and Girdler, 1964; Luyendyk and Melson, 1967; Watkins, 1968; Watkins and Harrison, 1968). In an alternative analysis, using a plausible marine geological section proposed by van Andel and Bowin (1968), Watkins and Richardson (1968) pointed out that "the relief plays a significant role in the compilation of the local theoretical model, and therefore emphasizes that a series of simple flat crustal blocks [as suggested by the Vine-Matthews model] is not likely to be the source of the local magnetic profile" – in their traverse of the mid-Atlantic Ridge at 22.5 N. The latter example issued a warning to the uncritical practice that had been established in marine-magnetic work: to force a fit of local observations to hypothetical geomagnetic polarity changes. As an example of the difficulty generally encountered in marine magnetic correlation work, Pitman and Talwani (1972) admitted that in the Central Atlantic "the anomalies are all generally quite difficult to correlate even between closely spaced profiles and with the theoretical models" (cf. **Fig. 7**). Although the linear magnetic anomalies were described as "perfectly" symmetrical about the mid-ocean ridge axis, this claim was little more than a delusion. In the attempt to correlate the complex anomaly system, invoking "ridge jumping" had become a model-bound trick.

A few mid-ocean ridge segments, such as the well-surveyed Reykjanes Ridge south of Iceland (e.g., Barron et al., 1966; Heirtzler et al., 1966; Godby et al., 1968; Talwani et al., 1971), have in the geophysical literature been regarded as a classical case for demonstrating that the anomalies are symmetrical about the ridge crest. To test the alleged bilateral symmetry, Agocs et al. (1992) carried out a qualitative study of 15 magnetic profiles oriented at right angles to the Reykjanes Ridge, representing a length of about 300 km of the ridge. 12 of these transects were sea-level profiles from Talwani et al. (1971), and 3 were aeromagnetic profiles from Barron et al. (1966). Various correlation coefficients, with limits between plus 1 and minus 1, were computed. The coefficient dealing with anomaly correlation across the ridge, the one of particular interest here, came out with the surprisingly low value of 0.17 – that is, there is no 'perfect' symmetry. Hence, the Vine-Matthews model was in trouble.

On the other hand, the Reykjanes Ridge is oriented along one of the fundamental orthogonal fracture sets, striking NNE. Thus, in the Upper Cretaceous-Lower Tertiary (Alpine climax), during which the crust of the northern palaeo-hemisphere was subjected to clockwise wrenching (including the moderate south-westerly swing of North America discussed above), the Reykjanes Ridge region was subjected to left-lateral shearing producing significant mineralogical changes along developing prominent fault zones – during which magnetic oxides were replaced by non-magnetic silicates. This means that the upper crust of the Reykjanes Ridge region developed a parallel NNE-oriented tectono-magnetic block system with varying magnetic susceptibility. In this explanation, prominent fault zones with the strongest mineral changes were characterized by negative field anomalies, while the intermediate less affected crustal segments had higher magnetic susceptibility (less altered) and thereby distinguished by positive field induced anomalies. Consequently, the magnetic field lineations along the Reykjanes Ridge can be considered products of the magnetic susceptibility-contrast model, for which there is no basis to predict bilateral symmetry. Moreover, prominent shear zones are the most fractured and most easily eroded part of the oceanic basement thereby commonly developing topographic lows. Positive correlation between bottom relief and marine magnetic anomalies has therefore a ready explanation.

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In response to the increasingly popular seafloor spreading model, forecasting an increasingly thick layer of marine sediments away from the ridge crest, studies were carried out to test this prediction. However, Ewing et al. (1966) and Ewing and Ewing (1967) found that the central 100-300 km wide strip along the ridges consist either of bare rock or of very thin sediment pockets. Along the ridge flanks, however, the sedimentary cover had relatively constant thickness, suggesting a uniform age for the flanks rather than a progressively increasing age as the seafloor spreading hypothesis predicted. The distinct variation in sediment thickness occurred well above the carbonate compensation depth, and hence the results were thought to be unaffected by differential solution. The conclusion was that recent spreading in the crestal zone could not be excluded, but, alternatively, the crestal zone might have undergone recent uplift with erosion and/or non-deposition. Anyway, the crestal event had been preceded by a longer period of seafloor quiescence during which a static flank deposits had accumulated. **Fig. 9** shows some of their graphs of sediment thickness versus distance from the ridge axis. Conclusions broadly concordant with those of Ewing et al. (1966) and Ewing and Ewing (1967) were obtained also by van Andel and Bowin (1968), in a study of the crest and upper flank of the Mid-Atlantic Ridge. It was suggested that the uplift of the Ridge was only a few million years old and could therefore be part of the same global pulse that elevated the continental mountain ranges. This conclusion is consistent with the development scheme of the Wrench Tectonics theory where all mountain ranges, regardless of their underlying basement/tectonic ages, are newcomers to Earth history (Storetvedt, 2003/23; Storetvedt, 2015; Michaelsen and Storetvedt, 2023 and references therein).

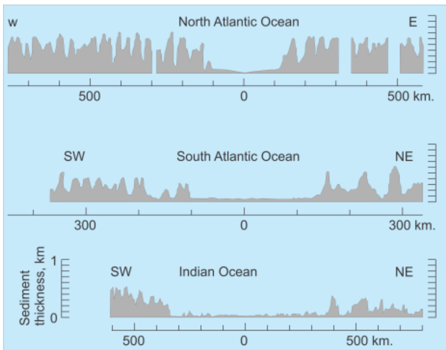

Fig. 9 Examples of graphs of sediment thickness versus distance from 'mid-ocean' ridge crests. Simplified after Ewing and Ewing (1967).

Play to the gallery

When continental drift, against all odds, gained recognition, the old counterarguments were ripe for renewed deliberation. Owing to the change of outlook provided by palaeomagnetic research, the resistance of the geoscientific community to drift had begun to yield. From reconsideration with more 'positive eyes' there gradually emerged a change of general attitude to the issue of continental mobility. Thus, pieces of evidence previously regarded as Cons were in less than a decade turned into Pros. Undoubtedly, the famous 're-enforcement syndrome' was strongly at play in the 1960s, at the time when documentation of continental breakup and Wegenerian drift were underway. The conversion process, from a very broad dismissal of drift before say 1960 to a nearly complete consensus shift towards its acceptance during the following decade, is generally, by the geoscience community itself, explained as a combination of new methods, novel crucial evidence, and intensive scrutiny. Unfortunately, the reality behind the scenes was/is quite different. The *Famous Atlantic Fit* (Bullard et al., 1965) which for decades were widely cited and hailed as a 'remarkable confirmation' of drift, is depicted in **Fig.10**.

Fig. 10 The fit of the adjacent Atlantic continents – based on Bullard et al. (1965). Due to "space problems", continental Central America, the Caribbean and various thick aseismic plateaus and ridges were omitted. Continental overlaps (in black) were therefore nothing more than embellished forgeries. The possible role of the fundamental pan-global fracture/fault system was not a topic of discussion and has not been since.

The popularity of the Bullard configuration was certainly because numerical methods were used for establishing the 'best' least squares fit, including optimization and error-testing. The great attention of "The Bullard fit" came primarily from the fact that it gave the appearance of being firmly rooted in mathematics – employing arithmetic methods and Euler's theorem for motions on a spherical surface and not least using an electronic computer (a novelty at the time). On the surface, the method seemed overwhelming, but the selected data base, on the other hand, was far from acceptable. The survey was nothing but a blatant misuse of mathematics. It is difficult to understand that an investigation which was essentially completely without scientific value could receive as much positive attention as it did. The so-called "Bullard fit" became a regular feature in geoscientific forums and for many years the most referenced article in the geoscientific literature. For most geologists, the mathematical analysis of the Bullard group seemed very sophisticated, but the refined methodology was effectively cancelled out by wishful thinking and the "need for regulation" of continental margins. The authors had ignored the parts of the crust that "got in the way" of achieving the desired adaptation.

The shallow continental-like Shetland-Faroe-Iceland Ridge and most other plateaus and ridges in the Atlantic were neglected. The submerged great continental Rockall Plateau, on the other hand, was accepted because it could be "fitted in". To avoid continental overlap between NW Africa and Iberia, the Bay of Biscay had been "closed", and continental Central America had been omitted. Central America was thus just as problematic as it had been in Wegener's time. But after the launch of the "Bullard fit", Central America was downplayed as a critical problem, although it was as acute as it had always been. Science analyst Homer Le Grand (1988) has described the work of the Cambridge group as improper data handling and that the phrase "garbage in, garbage out" was a good characterization of their "analysis". Scientifically it had no value – it had only been a show for the gallery. According to visiting researchers at Bullard's institute at the time (see Menard, 1986, p. 208), no one could remember that continental drift was on the table before Bullard's sudden interest. The question rises, therefore, whether Bullard had been infected by the "drift epidemic", a change of mentality that was on its way to occupying the collective mobilistic imaginary world among prominent British geophysicists. It is a fact that scientists (like other human groups) largely gain power, honour and positions by justifying and supporting intellectual fads. Also, Edward Bullard seems to have fallen victim to turning his cloak to the wind. During the increasingly strong tailwind of continental drift in the 1960s, several such "embraces" were witnessed (cf. Storetvedt, 2024, p. 96-103).

On persistent straying

In retrospect, it is easy to see that ignoring the broad and shallow transverse Shetland-Faroe-Iceland-Greenland (SFIG) ridge, to obtain the best "Bullard fit", along with neglecting other continental obstacles, was a sign that the new big picture thinking – plate tectonics, which was then on its way to gaining the upper hand in the global tectonic perception, would not be distracted by regional trifles. The SFIG ridge had traditionally been regarded a biogeographic land continuity between Europe and North America, to account for the strong pre-Middle Tertiary fauna and flora relationships between the two continents (e.g. McKenna, 1975, 1983). However, on floristic evidence this land connection had been open at least until the Middle Miocene. Thus, ever since Heer's (1868) pioneering work, the Miocene fossil flora of Iceland has continuously attracted palaeobotanists (e.g., Manum, 1962; Denk et al., 2005). A main point has been to compare Iceland's flora with North American and European taxa. In this context, Denk et al. conclude that "Although there is compelling evidence that plants colonized Iceland both from North America and Europe up to 12 Ma, migration in the younger formations (9-8, 7-6 Ma) is suggested to have occurred mainly from Europe." This implies that even in the latest Tertiary, a North Atlantic land connection was open at times.

In support of the land bridge concept, deep sea drilling on the northern flank of the SFIG ridge (DSDP Leg 38, site 336) encountered a 10 m thick sequence of lateritic paleosol interpreted as a deep subaerial weathering profile of Middle-Upper Eocene age (Nilsen and Kerr, 1976). It was concluded that the drill site had sunk at least 1000 m since the laterite layer was formed. At that time, the palaeoequator ran along the northern edge of Africa, placing the drilling site at c. 25°N. This accords well with fossil and rock evidence for European palaeoclimate (Wegener, 1929; Pomerol, 1982) and with the Tertiary palaeotemperature profile in the North Sea region (Buchardt, 1978). Already in the early 1970s, studies of the shallow Faeroe-Iceland Ridge arrived at an unusually thick crust – favouring a continental basement beneath the Faeroe plateau basalts (Bott et al., 1974; Bott and Gunnarsson, 1980). Several later crustal studies along the ridge (e.g. Staples et al.1997; Richardson et al., 1998) have basically confirmed the original conclusions. In a review of the North Atlantic evolution, Storetvedt and Longhinos (2011) concluded that Iceland, like the Faeroe islands, constitutes a thick continental crust capped by Neogene volcanics – subsequently cut by a few Upper Cretaceous-Lower Tertiary shear zones. In this interpretation, the Reykjanes Ridge and the tectonic rupture zone through Iceland become a left-lateral shear zone, in harmony with (Storetvedt, 2003/23; Storetvedt and Longhinos, 2011 and references therein).

A compilation map of crustal thicknesses in Northern Europe, Iceland and Greenland (Artemieva and Thybo, 2008, including many references) – **Fig. 11**, displays characteristic examples of the degassing-related crustal thinning/oceanization model which forms the basis of the Wrench Tectonic theory. It is likely that delamination and chemical transformation of the continental crust – towards an oceanic mode, will be gradational/spread-out rather than sharp. Thus, the crusts on the Baltic Shield and on Central Greenland show gradual thinning towards the deepest thin-crusted Norwegian Sea – where the depicted deep-sea segment has the shape of the ubiquitous orthogonal fracture network (Scheidegger, 1963, 1985, 1995). The same gradual crustal development is clearly visible in Greenland, where the crust has a central crustal keel. Moreover, the transatlantic Scotland-Greenland Ridge appears with a 30-40 km thick crust, and the featureless continental-like magnetic anomaly band that characterizes the ridge (Maus et al., 2008) provides further support in favour of its continental character. Hence, it is concluded that the shallow Scotland-Greenland Ridge represents the remains of an originally thick continental crust – a land bridge for biotic migration between North America and Europe.

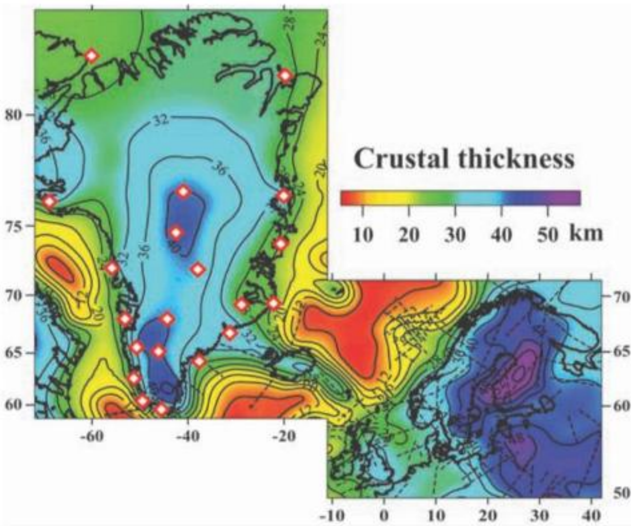

Fig. 11 Crustal thickness distribution in Northern Europe, Iceland and Greenland – compiled by Artemieva and Thybo (2008). Seismic stations in Greenland are marked by red diamonds. Note the thick crust of the Scotland-Greenland Ridge and the keel-like shape of the Greenland crust – where the latter shows progressive thinning towards adjacent oceanic tracts. See text for other details.

Unless one resorts to speculative ad hoc detours, seafloor spreading in the North Atlantic becomes a physical impossibility. Straightforward interpretations are always the most credible. If plate tectonics had not got the deep socio-scientific grounding as it has, modern technologies would have exposed the crustal thinning/oceanization process everywhere; the crust is apparently not thermochemically stable, in the Earth's relatively un-degassed state. The secret is to look at nature's expressions behind the curtains of plate tectonic, but the geoscientific insight slowly rolls on. Thus, Mortimer et al. (2017), in a compilation of rock evidence and geophysical crustal studies from an extended New Zealand (named Zealandia), "summarize and reassess a variety of geoscience data sets and show that a substantial part of the southwest Pacific Ocean consists of a continuous expanse of continental crust". They conclude that the former part of the hypothesized Gondwana today "is 94% submerged, mainly as a result of widespread Late Cretaceous crustal thinning …". Moreover, and in further harmony with the crustal attenuation/oceanization model, the authors submit that "Whereas most of Zealandia's crust is thinner than the 30-46 km that is typical of most continents, the above studies show that it is everywhere thicker than the ~ 7 km thick crust of the ocean basins".

Today's factual basis is much greater than it was in the 60s when plate tectonics made its revolutionary entry. The 'new global tectonics' was strongly pushed forward by Tuzo Wilson's introduction of two new concepts – transform faults and the Wilson Cycle (Tuzo Wilson, 1965; 1966). Even after Tuzo Wilson (1992) eventually wrote off plate tectonics and argued for the necessity of an entirely new geophysical-geological paradigm, the Wilson cycle lives on as a popular term without a clear content; under this umbrella everything seemingly goes. It is a strange fact that (geo)science does not seem to be able to correct old mistakes, even when later research has shown that there may be something seriously wrong with the initial premises. However, over time the original plate tectonic assumptions have become deeply entrenched doctrines topped up by a steady growth of hypothetical ad hoc embellishments. This situation makes it very difficult to reconsider old mistakes.

First critical test – with unrealistically high expectations

By the late 1960s assumed magnetic age isochrons had been established over extensive regions of the world oceans. But with the magnetic method being based on a chain of unverified assumptions, more direct confirmations of basement ages were needed. The Deep-Sea Drilling Project (DSDP), initiated in 1968, was soon directed towards these targets. The objective was to sample the marine deposits down to basement. Through palaeontological dating of the sediments immediately above the crystalline crust, it was hoped that the magnetically based basement ages would be verified. A transect at 30°S was chosen for this crucial test (DSDP Leg 3, sites 14-21). The results from the 8 sites were soon hailed as having substantiated the seafloor spreading model (Maxwell et al., 1970). **Fig. 12** shows the distribution of South Atlantic DSDP sites (a), and (b) depicts the published plot of suggested basement ages versus increasing distance from the ridge crest.

But those who took time to critically study the achieved results – site by site, would realize that the submitted age/distance graph was fraudulent (cf. Storetvedt, 2023, p. 89-94). The almost perfect linear graph that was published was too idealized to be true; something dishonest was brewing. But according to the shipboard report the results were in accord with the studies of marine magnetic field anomalies (e.g., Dickson et al., 1968; Heirtzler et al., 1968).

It seemed that most accepted the conclusions uncritically, but in certain circles people must have tacitly discovered the deception. Because subsequently supplementary drilling was carried out along the same profile in the South Atlantic without these leading to clarifying results (DSDP Leg 39, 72 and 73; see **Fig. 12a**). One that spoke out his mind about what had happened, was Professor John Haller (Harvard). At a guest lecture in Bergen in the fall of 1977, Haller described the DSDP Leg 3 conclusions as an

NCGT Journal
New Concepts in Global Tectonics

New Concepts in Global Tectonics Journal
Volume 14, Number 3, March 2026

ISSN number; ISSN 2202-0039

example of outright scientific fraud – shocking the Bergen audience. However, the plate tectonic mass conversion was in full swing, so individual warnings fell on deaf ears. The Leg 3 shipboard scientists had undoubtedly been in a forced situation. They had obviously not gone to sea to see what they would find, instead let themselves be led by the strong pressure to confirm an already "accepted conclusion".

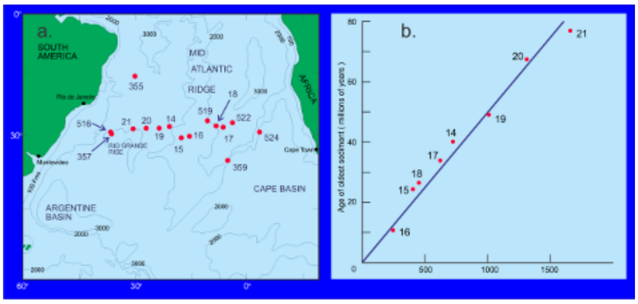

Fig. 12 Diagram a) shows the distribution of DSDP sites across the South Atlantic (Legs 3, 39, 72 and 73) that attempted to confirm the combined seafloor spreading model and the Vine-Matthews dating hypothesis. Diagram b) shows published basement age/distance relationships from Leg 3 (Maxwell et al., 1970), but the diagram was not consistent with the observations. The hopes were also not fulfilled in later attempts (cf. Storetvedt 2003/232, Fig. 2.12).

At Keith Runcorn's *NATO Advanced Study Institute* in Newcastle in spring of 1969 (where I was present), the meeting received a telegram from the drilling ship, *Glomar Challenger*, announcing that the seafloor spreading model had been confirmed. At the meeting, the news was met with ovations. And in the following years, the hallelujah mood just continued. For example, in his widespread textbook *The Interior of the Earth*, Martin Bott (1971, p. 220) uncritically embraced plate tectonics, though his exaggerated praise of the published Leg 3 graph (Fig. 12b) was completely unfounded. None of the drilling sites in the 30°S transect seem to have reached basement – only intra-sedimentary intrusions. Storetvedt (1997, p. 96-103) gave a critical summary of the intra-sedimentary magmatic pulses encountered in Leg 3 sites – arriving at ages of around 45, 65 and 90 Ma respectively (cf. Storetvedt, 2023, p. 93). Bott was a seismologist, and his field of expertise was therefore far from the geophysical disciplines on which plate tectonics was contrived.

Perhaps the most unexpected result from Leg 3 was that all boreholes in the trans-ocean cross-section lacked late Miocene sediments – resulting from erosion and/or non-deposition. Such a consistent absence of a sedimentary section across the ocean is a conundrum in the seafloor spreading model. In the case of a steady-state seafloor evolution, one would anticipate a systematic cooling associated crustal subsidence with time – giving rise to a progressively thicker sedimentary pile versus increasing water depth. This was contrary to the observations. In addition to the general absence of late Miocene sediments in the Leg 3 transect, the Miocene and younger deposits on Grande Rise (site 21) had been laid down in considerably shallower water than the local pre-Miocene sequence. This indicates that in the late Miocene the entire South Atlantic was uplifted – a conclusion that concorded with that of van Andel and Bowin (1968) suggesting that uplift of the Central Atlantic Ridge was only a few million years old and could therefore be part of the same global pulse that elevated the continental mountain ranges (see also Storetvedt, 2015; Michaelsen and Storetvedt, 2023). In harmony with this interpretation, low lying continents ought to be flooded by shallow epicontinental seaways. For example, **Fig 13** depicts how the missing upper Miocene sediments of Leg 3 (figure a) correspond to extensive flooding of South America (figure b). As was reported in the Initial Leg 3 Reports, the thickness of the sediments bore no simple relation to the age of the sediments. Thus, it was considered a paradox that the drill hole with the suggested youngest basement had the greatest sediment thickness, whereas the assumed oldest had the thinnest sedimentary cover (above seismic basement). In the Initial Reports, it was further expressed that "the nature of the sediments below the topmost formation bears no simple relationship to the present depth of the drill site, indicating changes in the depositional environment at each site with time. Paradoxically, the sedimentary sequence at the drill site where the present oceanic depth is the greatest has the highest average calcium carbonate content". Again, it follows that such bewildering observations are problematic only in the context of the seafloor spreading model. If we instead accept the probability that Leg 3 did not reach basement in any of the drill holes, and that the encountered basalts represent intra-sedimentary intrusions or extrusion – for which the igneous horizons are products of tectono-magmatic events having affected the entire width of the ocean, then interpretation of recovered material would be much simpler. The alleged spreading history would be replaced by the oscillating development of the deep-sea crust in phase with eustatic sea-level variation – thereby representing a snapshot of Earth's pulse-like behaviour.

Problems reach new peaks

According to the seafloor spreading hypothesis, the crust along the mid-ocean ridges has formed during the last few million years. On this assumption, palaeomagnetic inclinations from basalts of the crestal zone should correspond to that of the of Present Axial Dipole Field (PADF). If such an agreement with theory had been confirmed by palaeomagnetic measurements in deep-sea drilling material, it would have provided strong evidence in favour of the spreading hypothesis. Thus, comprehensive palaeomagnetic tests have been carried out on basalts near the Central Atlantic Ridge axis – DSDP Legs 37, 45 and 82, but with very few exceptions the various basement sections studied are characterized by remanence inclinations significantly shallower than the corresponding reference field. The most detailed geological and geophysical

ISSN number; ISSN 2202-0039

information is available from Leg 37, drilled in a transect on the western flank of the Central Atlantic median valley at 37°N. This drilling cruise, which was carried out in May-June 1975 (with Initial Reports published in 1977), included 4 drilling sites (332-335) for which localities 332 and 333 were said to be "drilled along a seafloor spreading flow line". At this time, the terminology of plate tectonics was already so deeply rooted in marine crustal studies that any doubt about seafloor spreading was unthinkable. The purpose of Leg 37 (and other corresponding deep drilling campaigns along the Central Atlantic Ridge) was primarily a) to get a final confirmation of the Vine-Matthews model as well as b) to confirm the model's petrological and magnetic properties. However, the obtained results were in radical contrast to expectations.

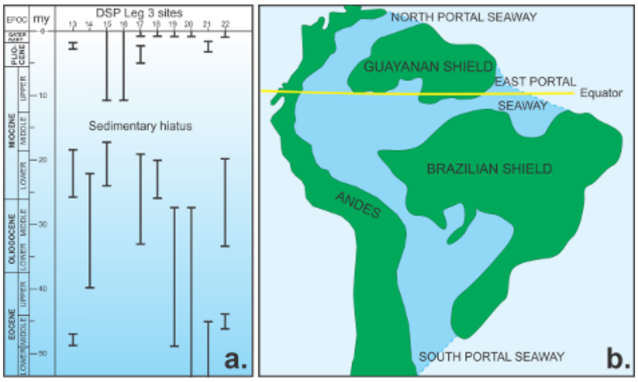

Fig. 13 Figure a) depicts the pronounced trans-oceanic sedimentary hiatus from DSDP Leg 3, interpreted here as a major phase of uplift of the South Atlantic crust with resulting erosion and/or non-deposition. In comparison, figure b) shows the concurrent transgressive seaways across South America – slightly modified after Webb (1995).

Fig. 14 illustrates the distribution of DSDP Legs 37, 45, 82 on the Central Atlantic crest, along with the crossing Upper Cretaceous-Lower Tertiary palaeoequator – originally described by Wegener (1929) on basis of palaeoclimatic and later underpinned by palaeomagnetic data (Storetvedt, 1990, 2023). Under normal scientific circumstances, these drilling campaigns would have served as a decisive test of the Vine-Matthews model. But how could an already entrenched idea be tested when already taken for granted? According to the hypothesis, the upper oceanic basement would act as a kind of tape recorder of the changing geomagnetic polarity during the last few million years, thereby dating the newly formed oceanic crust in its spreading away from the mid-ocean ridges. On this assumption, palaeomagnetic inclinations in the crestal zone should correspond to that of the latitude-dependent Present Axial Geocentric Dipole Field (PADF). Leg 37 (Aumento et al., 1977) gave the most detailed petrologic and magnetic information – drilling up to 583 m into oceanic basement at site 332 B. With very few exceptions the various basement sections studied are characterized by remanence inclinations significantly shallower than expected values. For Leg 37 sites the PADF is c. ± 56°, but the measured remanence inclinations are in the range of only ± (10-30°). For Leg 45 (at 23N) the PADF is c. ± 40°, but the histograms of stable inclinations (Johnson, 1979) are again much shallower than the seafloor spreading model predicts. On the contrary, the measured inclinations are in good agreement with the orientation of the Upper Cretaceous-Lower Tertiary palaeo-equator shown in **Fig. 14**. That is, regardless of whether the paleomagnetic data are original or remagnetised, the mid-Atlantic crust is not young – at least it existed in the Upper Cretaceous. In all probability, the Central Atlantic was originally covered by thick continental crust that has undergone extensive thinning and petrological transformation – a process that accelerated in the Upper Cretaceous.

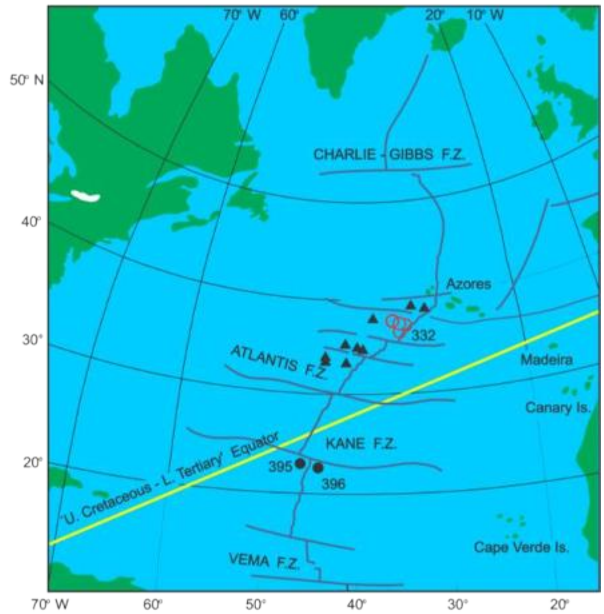

Fig. 14 DSDP sites on the Central Atlantic Ridge, with the intention of testing the Vine-Matthews hypothesis. Open circles, Leg 37 (sites 332-335); filled circles, Leg 45 (sites 395 and 396); filled triangles, Leg 82 (sites 556-564). For comparison with measured palaeomagnetic inclinations, the Upper Cretaceous-Lower Tertiary equator is shown by yellow line. The test results were unsuccessful. See the text for details.

In a review article describing the drilling results from the North/Central Atlantic Ridge, two of the principal scientists of Leg 37, Hall and Robinson (1979) wrote: "Oceanic crustal drilling by R. V. Glomar Challenger at 15 sites in the North Atlantic has led to a complex picture of the upper half kilometre of the crust. Elements of the picture include the absence of the source for linear magnetic anomalies, marked episodicity of volcanic activity, ubiquitous low temperature alteration and evidence for large scale tectonic disturbance". Apart from the crucial palaeomagnetic

ISSN number; ISSN 2202-0039

inclination problem, other highlighted model complications can be summarized as follows:

* Vertical and uniformly magnetized crustal blocks (sheeted dikes) with alternating fossil-magnetic polarity, the very basis of the Vine-Matthews model, were not found.

* A palaeomagnetic source for the magnetic anomalies was also not observed. Measured intensities of magnetization were too weak to explain the observed field anomalies as palaeomagnetic signatures.

* Lava flows and plutonic masses behaved completely unsystematically – in stark contrast to the spreading model's simple intrusive block system (sheeted dykes).

* In terms of rock type and stratigraphy, the crystalline bedrock in Leg 37 was without any form of lateral continuity.

* Several conditions indicated that the crustal build-up was episodic and geologically disordered – not simple and uninterrupted as the spreading model assumed.

* The measured heat flow in the Leg 37 area was extremely low (0.6 HFU) even on a worldwide basis, and an order of magnitude lower than what the spreading model assumes.

The DSDP Leg 37 rock highlights do not represent special cases; rock age diversity, structural complexity and varying degree of metamorphism are characteristic features along the Central Atlantic Ridge. For example, Pilot et al. (1998) reported Palaeozoic and Proterozoic U-Pb ages from exposed gabbro beneath the Mid-Atlantic Ridge. Instead of considering the simplest and most realistic explanation – namely, that these ancient rocks are remnants of in situ transformation of an original continental crust, the authors put forward a complicated plate tectonics-laden proposal. However, the presence of unabsorbed continental ridges and plateaus, at various depths in the oceans, abound. For example, within a larger area just north of the Azores and east of the Mid-Atlantic Ridge, Lower Palaeozoic fossiliferous sediments have repeatedly been recovered from seamounts since the late 1800s (e. g., Furon, 1949). In the same general region, on Bald Mountain at 45°N and 60 km west of the Median Valley, Aumento and Loncarevic (1969) recovered an association of metamorphosed and unmetamorphosed basalts from steep slopes, but from the more massive part of Bald Mountain some 75 % of 84 obtained samples was a diversity of sandstones, limestones, gneisses, granites, granodiorites, granulites and amphiboles. Yano et al. (2009) have described ancient and continental rocks from 42 localities in the Atlantic crust.

Regarding the heat flow problem, all theoretical conductive cooling models predict very high heat flow, c. 6.5 HFU (1 HFU=1cal $cm^{-2}s^{-1}$) along the crestal zone (e.g., Sleep, 1969; Davis and Lister, 1977). In contrast, many measurements depart markedly from the expected figures. In general, ridge crests show very large scatter in heat flow values – with local highs among a nearby population of dominantly low magnitudes. The smoothed means are very close to the mean basin average (c. 1.3 HFU) – much below that predicted by theoretical models. According to Lister (1980), thermal lows at the crestal region occur particularly in the flat-floored median valley, i.e. in a setting which according to the spreading model should be the hottest. On the other hand, thermal highs (where they exist) may be located within adjacent areas of rugged topography and frequently near steep fault scarps. In the degassing Earth theory, the locally elevated heat flux would naturally take place along prominent fracture zones and/or in wrench tectonics crustal breakup chimneys. As a characteristic example of the distribution of oceanic heat flux, **Fig. 15** shows data for the Central Atlantic compiled by Rona (1980), with addition of the DSDP Leg 37 measurement. It is readily seen that there is little difference in thermal flux between the mid-ocean ridge and the remaining part of the ocean. Two trans-Atlantic heat flow profiles at 19.5°N and 8.5°S respectively (von Herzen and Simmons, 1972) underlines the general picture. Apart from a few scattered higher values, the two profiles show predominantly flat and low thermal fluxes centred around c. 1 HFU. Low heat flow values from the oceans have continuously been reported. For example, on DSDP Leg 26 across the southern Indian Ocean, established heat flow values from 5 sites were as follows: 0.7 east of Mozambique Basin, 1.35 and 1.27 on the Ninety East Ridge, 1.10 and 1.38 in the Wharton Basin – and no trend versus alleged seafloor spreading ages was found (Hyndman et al., 1974). When textbooks show mid-ocean ridges in red (warm) colour, this is a good example of scientific falsification.

It is a paradox indeed that once a scientific theory has gained foothold, its fundamental problems are either ignored or not seen at all. In fact, crucial tests that turn out to be negative (versus the ‘well-received’ hypothesis) is normally either disregarded as an anomalous deviation or subjected to unwarranted ad hoc interpretation. The possible inadequacy of the model itself (to account for nature) is barely considered. Unfortunately, “it is all too easy to derive endless strings of interesting-looking but untrue or irrelevant formula instead of checking the validity of the initial premises” (Ziman, 1978). Below we will go back a hundred years to the seed of what in the 50s became the prelude to the plate tectonic revolution a decade later – which nevertheless led to the geosciences losing their footing.

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New Concepts in Global Tectonics Journal
Volume 14, Number 3, March 2026
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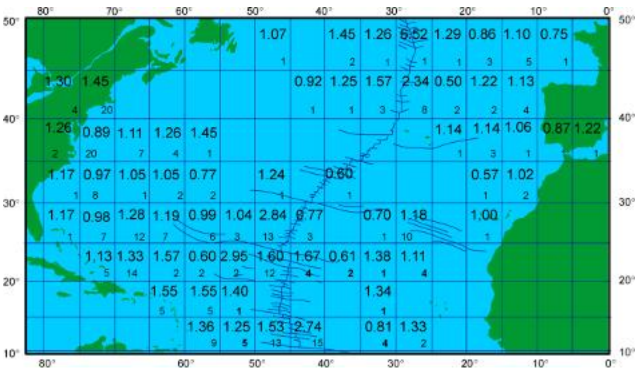

Fig. 15 Heat flow (HFU) map of the Central Atlantic, compiled and simplified after Rona (1980), with the Leg 37 observation added. Lower number inn each compartment denotes number of observations.

To square one

Within today's geosciences, Alfred Wegener is considered the most farsighted innovator of the 20th century. But when his hypothesis of continental drift was launched around 1915 it received mixed receptions – shrugs, joke making, a few vigorous rejections, but rarely if at all seriously debated. Ursula Marvin (1985), Homer Le Grand (1988) and Naomi Oreskes (1999) have given historical accounts of the hypothesis's near-unanimous negative reception. In the geological literature from the interwar period, it is striking how emotional and scientifically superficial the drift hypothesis was met. For most geologists and geophysicists, drifting continents were an impossibility – it was a foreign element in geology, and above all, the driving forces were missing! Even in today's geosciences, with plate tectonics being the overarching theory, the driving mechanism remains an unresolved issue. But since drifting plates, platelets and continental blocks have now become a matter of course, where postulated movements are apparently without physical and other restrictions, ad hoc proposals to avoid/remove 'obstacles' are just seen as necessary for scientific progress. That is, since the answer is given, nature must adjust accordingly.

Wegener also had a few ardent supporters in which the prominent South African field geologist Alexander du Toit played a leading role. Below, we will give an outline of the drift hypothesis' dubious claims and contrary facts. The strange thing is that even today the same problems are open and unresolved, but no one seems to care or is willing to spend time on observational and kinematic paradoxes (see also Gregori, 2025, in 6 separate issues of NCGT Journal. In teaching, therefore, the student is likely to pick up a grossly oversimplified and uncritical view of the subject. In the pre-middle 1950s, continental drift sustained colloquial interest because it was so dramatically different from conventional conceptions about the Earth – and besides, it had "audience success". The PR effect is obviously as important in science as in other human activities.

Polar wandering and the zonal system of latitude-dependent palaeoclimate

As well as being primarily a meteorologist, Wegener had strong interests in global paleoclimatology – particularly regarding the episodic change of the equatorial belt since the early Palaeozoic. In his time, it was well-established that the northern continents had experienced tropical to subtropical climates throughout most of the Phanerozoic, but the relative tropical belt had shifted south. Thus, in Europe the tropical belt had changed from the Spitsbergen/North Polar region in the Lower Palaeozoic, via Central Europe in Permo-Carboniferous time to southern Mediterranean in the Lower Tertiary. This meant that even as late as the Lower Tertiary Spitsbergen and North Greenland experienced warm intermediate latitudes characterized by its luxurious land vegetation (Wegener, 1929), while the corresponding North Pole was in the western Aleutians. Then, around Middle Tertiary the equator moved to its present relative position, instituting approximately the Earth's present spatial orientation. After this spatial change of the globe (true polar wander), both Arctic and Antarctic regions had become polar for the first time since the Precambrian. Unfortunately, Wegener disregarded this important point; he had his own ideas about how to handle climates and biogeographic evidence from the southern continents.

Nevertheless, in Wegener's own words "this enormous climatic shift – in Europe from tropical to temperate, in Spitsbergen from subtropical to polar – immediately suggests a shift in the poles and the equator, and thus the whole zonal system position of climates. In fact, this suggestion is inescapably confirmed by the equally large, but exactly reversed climatic change experienced by South Africa … in the same period". He further added: "These fully authenticated facts permit of no other explanation than that of polar wandering. We can make yet another test of this. If the meridian through Spitsbergen and South Africa passed through the greatest climatic change, then the simultaneous change in the two meridians 90°E and 90°W must have been nil or insignificant; and this is in fact the case" (Wegener, 1929/66, p. 127-128). **Fig. 16** depicts the palaeoequatorial arrangement as per Wegener's description. When corrected for c. 25° of a late Cretaceous-early Tertiary south-westerly rotation of the upper crust of North American discussed above (cf. Figs. 2 and 3), around a Euler pole in northwestern Canada, the continent's

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reorientation achieves an even better match with Wegener's palaeoequatorial system. Wegener's palaeoclimate based polar wander path was later confirmed by a broad-based palaeomagnetic evaluation (Storetvedt, 1990), but with the difference that Wegener's (1929) "Spitsbergen-Cape Town line" has been shifted slightly westward to the Greenwich meridian plane (cf. Fig. 4b in Michaelsen and Storetvedt, 2023).

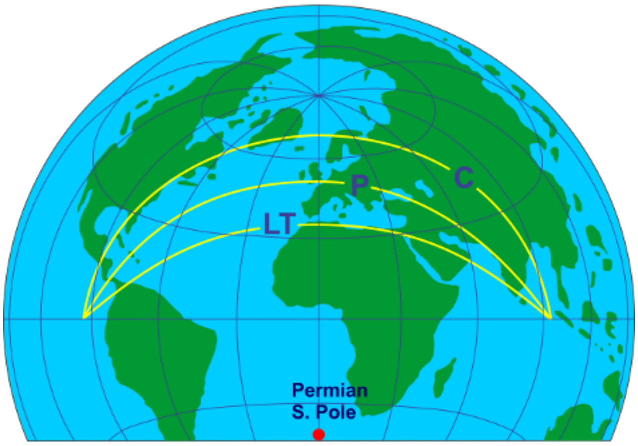

Fig. 16 Paleoclimatically-based equators from three different epochs: Carboniferous-Devonian (C), Permian (P) and Upper Cretaceous-Lower Tertiary (LT), drawn from description in Wegener (1929/66). The Permian South Pole is marked by red symbol.

In Wegener's zonal palaeoclimate system, the Middle Palaeozoic (Devonian-early Carboniferous) pole would be located off northern Namibia, late Palaeozoic (late Carboniferous-Permian) pole situated a little south-west of South Africa, while the Lower Palaeozoic pole would be positioned in NW Africa. Late Ordovician polar glaciation in western Sahara has indeed been underpinned by modern geological studies (Tucker and Reid, 1973; Ghienne, 2003; Le Heron et al., 2007; Le Heron and Howard, 2010) – in overall agreement with Spjeldnæs' (1961) spatial orientation of the Earth at that time. Moreover, if the continents are allowed to retain their current relative positions, and at the same time accept Wegener's polar migration path – in the form of a progressive shift in the spatial setting of the globe in the direction of the present Pacific, the obviously disturbing palaeoclimate evidence from Antarctica would have had a simple and straightforward explanation. This would mean that the Arctic region and Antarctica have had similar paleoclimatic histories. While the polar axis during the Palaeozoic went through Africa, polar conditions changed from north-western to southern regions of the continent. According to both Wegener and later Storetvedt, the last stage in the progressive post-Precambrian polar migration path, which amounted to c. 35 degrees of latitude, occurred around mid-Tertiary. **Fig. 17** shows a modern fossil-based demonstration of the latter dynamic event, after which Antarctica became polar for the first time since the Precambrian.

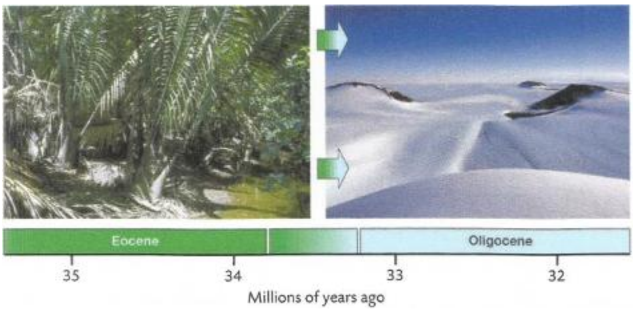

Fig. 17 Demonstration of the major climatic shift that took place in Antarctica around the Eocene-Oligocene boundary (Elderfield, 2000). During this 35° latitudinal flip of the Earth, in the direction of the Pacific (Storetvedt, 1990, 2003/23), both Antarctica and the Arctic achieved polar positions.

During the Phanerozoic, the Earth's body thus underwent an approx. 90-degree spatial shift near the Greenwich plane, in the direction of the Pacific. Referring to Wegener's climate-based polar wander path, the relative late Palaeozoic pole was in the vicinity of South Africa which also was, and still is, regarded the major glacial centre at that time. So, with Antarctica in its present geographic position, its 'Permian' palaeolatitudes would correspond to warm intermediate to tropical conditions (**Fig. 18**). This is consistent with the fossil climatic basis that already had been established in Wegener's time (see review articles in Tingey, 1991). It is strange that this global first-order climate zoning of the geological past does not seem to have engaged palaeoclimatologists and palaeontologists to any extent. But evidence has been available for at least a century that the climate shift in the Arctic region and in Antarctica has been analogous – varying from tropical and/or subtropical in the Lower Palaeozoic to overall warm intermediate conditions in the lower Tertiary, followed by a marked transition to polar conditions in the middle Tertiary. Thus, Heer (1868-1880) gave a detailed description of rich Lower Tertiary flora at present-day high northern latitudes and referred them to a warm temperate climate. Heer's palaeobotanical conclusions accorded with the broader based evidence of Köppen and Wegener (1924) who placed the North Pole of the time in the Aleutian region, with the associated palaeoequator along the southern rim of present-day Mediterranean (Pomerol, 1982).

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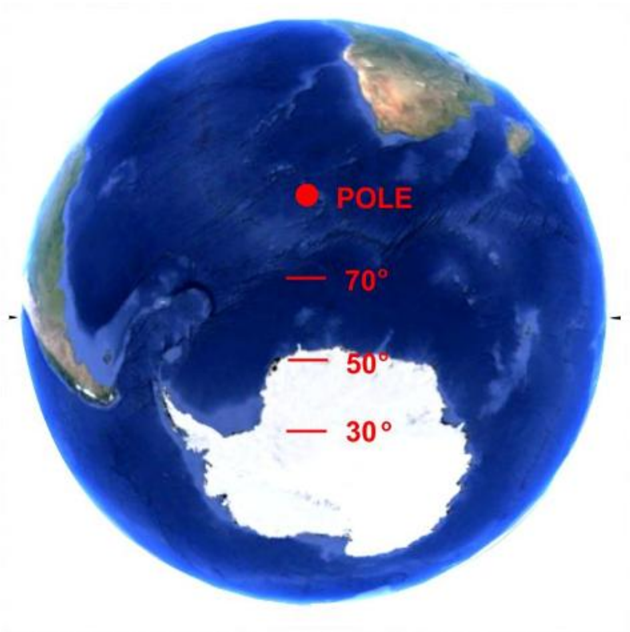

Fig, 18 The illustration shows the Permian latitudinal situation for Antarctica, starting from the palaeogeographical pole from Fig. 16, and with the continents in their current geographical location.

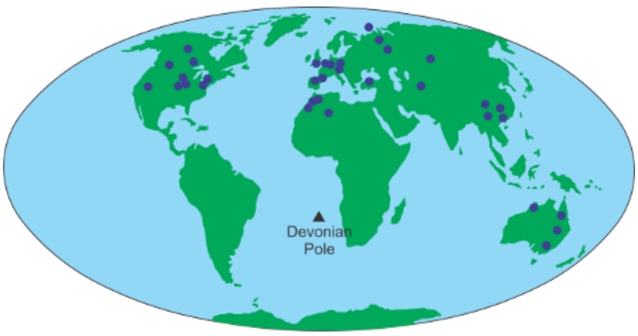

Fig. 19 Based on tropical-subtropical localities of red sandstone, evaporites, and warm fossiliferous shallow-water deposits, Schwartzback (1963) established a best-fitting Devonian palaeoequator. By extension, this tropical belt will pass over Antarctica, which is therefore consistent with the continent's fossil evidence. The associated pole position (triangle) is off Namibia.

Fig. 19 presents the Devonian tropical belt as an approximate great circle – envisaged in pre-plate tectonic days (Schwartzbach, 1963), with the corresponding South Pole off northern Namibia. If one allows Antarctica to retain its current geographical position, extension of Schwartzbach' palaeoequator would pass across Antarctica – in accordance with the continent's fossil evidence.

More recently, ODP Leg 119, drilling on the Antarctic margin in Pryds Bay, obtained shallow palaeomagnetic inclination from a thick red bed sequence of supposedly Devonian age (Keating and Sakai, 1988). Both the presence of red beds and their near-horizontal remanence inclinations concur with the fossil evidence – that is, that Antarctica had (sub)tropical conditions during the Middle Palaeozoic. Furthermore, if we expand Wegener's northern hemisphere based Permian equator (**Fig. 16**), it will pass through India and Australia, and with further extension across (or close to) Antarctica. This gives a 'first order' sketch of the global palaeoclimate system. But Wegener believed that certain floristic and climatic factors suggested that, in addition to the polar wandering phenomenon he had established, India and the southern continents had been a unified entity – a postulated unification that stumbled right from the beginning.

Classical facts and multiple hypotheses

Prior to Alfred Wegener's entry into the geoscience arena, global tectono-topography was dominated by the grand views of Eduard Süss. In a four-volume treatise synthesizing the geological information throughout the world – *Das Antlitz der Erde* (Süss, 1883-1904), with English edition, *The face of the Earth* (Süss, 1904-09), he presented a mobilistic theory that nearly reached consensus status towards the turn of the 19th century. Süss' comprehensive theory, which was based on Earth contraction, was episodic – longer periods of tectono-topographic tranquillity had been interrupted by relatively short intervals of global change in consistency with earlier proposals and the growing perception of build-up of the geological time scale. According to Süss, the continental crust, assumed to have initially covered the whole of the Earth's surface, had fragmented and in part subsided to oceanic depths (caused by thermal shrinking). Continental and oceanic crusts were compositionally similar and interchangeable. Certain faunistic similarities/peculiarities around the present-day Indian Ocean and the South Atlantic were explained by assuming the existence of a former large palaeocontinent in the Southern Hemisphere, Gondwanaland. After a large part of this hypothetical land mass had been tectonically fragmented and submerged (resulting from thermal contraction), the former supercontinent had been divided into smaller units. This scenario must have infected Wegener.

However, with the growing evidence that the marine deposits on the continents had generally been deposited in shallow water, this oscillating crustal model was seriously challenged. Nevertheless, the model was able to explain two prominent geological facts: 1) the gradual retreat of the ocean from the continents (progressive regression) was achieved by drainage into sinking ocean basins, and 2) faunal similarities between currently separated land regions were accounted for by assuming that larger parts of the palaeocontinents had been tectonically disturbed and had sunk, which had led to oceanic barriers of migration of land fauna and flora. However, it was easy to imagine that the shrinking/subsiding continental crust had left unaffected transoceanic continental connections. This was the basis of the palaeontologist's popular theory of 'land bridges', to explain biological migration routes between land regions in the recent geological past. In Süss' world, the Tethys was a long, shallow and relatively narrow intracontinental seaway that had formally linked the Mediterranean, southeastern Asia and the Caribbean – separating a northern and a southern palaeo-landmass.

Studies of the grand scale orientation of fold belts made a major leap ahead in the later decades of the 19th Century; the tectonic axes tended to follow great circles on the globe. Based on Süss' view, Bertrand (1887) concluded that the mega-tectonic belts in Europe – Caledonian, Hercynian and Alpine, had their continuations westwards in eastern North/Central America. The trans-Atlantic segments were hidden by the tectonically depressed North Atlantic crust. According to Süss, the oceans had been growing steadily for a long time at the expense of land areas. However, gravity measurements around the turn of the century broadly confirmed the principle of isostatic compensation of the main surface features. Consequently, the oceanic crust apparently consisted of denser material than the continental crust, which in association with Henry Becquerel's discovery of radioactivity in 1896, led to confusion about the validity of prevailing tectonic models (contraction and isostasy). However, the late 1800's and early 1900's were times of innovative ideas about inner forces affecting surface tectono-topographic features. Thus. Le Conte (1889) presented a generalized model of the Basin and Range Province (in western USA) arguing that it had been formed by crustal arching and extensional fragmentation. He wrote: "The arch was not formed by lateral pressure but by tension of lifting, caused by intumescence of subcrustal liquid". Later Barrell (1914) reasoned that due to vertical magmatic infiltrations of the outer shells, the soft or plastic zone beneath the crust (which he named asthenosphere) was unlikely to be sharply defined, and a schematic new view of the formation of fold belts was afforded by Kober (1923). In Kober's view, lateral compression had caused upward squeezing of the tectonic belt giving rise to the development of bilateral thrust systems and exposure of the pre-deformation crustal core.

Furthermore, Barrell (1927), in a paper completed in 1919 but published posthumously 8 years later, suggested that the problem of biological homologies could be accounted for within the framework of permanent continents. He argued that massive injection of basic magma into the original felsic crust, topped up by surface volcanism, would increase crustal density (and its loading effect) to the extent that subsidence would ensue. Barrel could point to a few remaining continental segments, notably in the North Atlantic, that made it likely that his postulated mechanism of crustal transformation and subsidence had been operative. He concluded that the deep-sea basins had also been formed in this way, and the biogeographers' land bridges were nothing but remnants of former continental crust that had undergone a delayed transformation and subsidence development. Under the auspices of a degassing Earth, Barrell's crustal oceanization theory – by chemical transformation and elimination of continental crust, can now be viewed from a quite different angle of view (see below).

Already at the turn of the 19th Century, Chamberlin (1897) turned away from traditional thinking by proposing that the terrestrial planets had formed primarily by a mix of gas and rocky dust particles. In consequence, it was proposed that the Earth began as a cold body that had gradually heated up, due to radioactive material with heat production distributed throughout its mass. An initial Earth with cold gas and particulate matter could well have maintained at least part of its primordial heterogeneity and, therefore, still be in a state of internal differentiation with associated outgassing even today. In the same sense, Hixon (1920) suggested that many tectonic processes were diapiric phenomena caused by planetary gas release. The enormous volcanic events of ash ejection and gas blowouts in the 19th Century – Mt. Tambora (1815) and Krakatau (1883) – may have sparked this idea. And Ampferer (1944) reiterated the possibility of subsurface gas pressure powering vertical tectonic phenomena. The latest references tell us that the idea of a not fully outgassed Earth has a long history. Already when the Earth's core was discovered (Oldham, 1906) it was suggested that it might have a certain density deficit. In more recent times, Urey (1952) reiterated the old view of Pierre-Simon Laplace and Immanuel Kant (late 1700s) and Chamberlin (1897) that the Earth and the other terrestrial planets of the solar system had formed by a flattened nebular disk, comprising a cold mix of gas (mostly hydrogen) and rock elements. Urey argued that the expected very slow mass reorganization and chemical differentiation of the Earth's body, into a metallic core and silicate shells, could well be incomplete and therefore still in progress. This incomplete outgassing is apparently the very motor of Earth's episodic dynamo-tectonic history (Storetvedt, 2003/23).

Barrell's crustal transformation theory was influential for decades. For example, many of his reasonings can be found in Hans Cloos' model of continental rift basins (Cloos, 1939), and the oceanization model of Vladimir Beloussov also rests on Barrell's ideas (Beloussov, 1962). **Fig. 20** shows Cloos' block diagram of the formation of rift basins (graben formation) – with uplift, volcanism, and finally subsidence along one of the sets of the steep orthogonal fracture network. Cloos' diagram can be seen as an early phase of Barrell's oceanization model. Furthermore, the figure shows that Cloos was well acquainted with the fundamental and ubiquitous orthogonal system of rock discontinuities – occurring in all dimensions, from small joints in road cuts to large-scale transcurrent faults. If we combine and laterally extend the crustal models of Joseph Barrell and Hans Cloos, the result would easily be ocean basins with parallel opposing margins. However, for parts of the Earth's crust that have undergone large-scale

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oceanization, such as in the Indian and Pacific oceans, the principle of coastal parallelism has been lost, while in the relatively narrow Atlantic it has been preserved.

Wegener's derailments

According to Wegener himself, it was the recognition of the geometric match of the coastlines bordering the South Atlantic that (in 1910) first captured his interest in palaeogeography. After a cursory reading of the relevant geological and palaeontological literature, he soon developed a critical attitude towards the established hypothesis of land bridges – invoked to account for intercontinental biological exchanges. It was assumed that these transoceanic land connections had subsequently broken up and sunk to variable ocean depths.

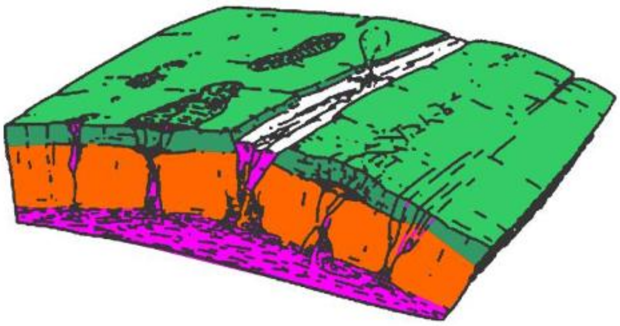

Fig 20 Hans Cloos' model for development of continental rift basins (Cloos, 1939). See text for details.

For Wegener – who held on to the traditional view of an originally molten globe that had subsequently undergone cooling and chemical differentiation, giving rise to an iron-rich core and a light granitic top layer – the idea of sunken land bridges ran counter to the isostatic principle. But if so, what had happened to the missing granitic layer in oceanic regions, and what about the established density difference between the continental and the oceanic crust? To avoid these problems, Wegener hypothesized that a thin sialic shell had somehow been joined, by inertial forces, to a thicker but area-reduced continental mass, Pangea. This postulated supercontinent had then undergone reorganization into the present pattern of continents – again by assumed inertial effects. But how the same dynamo-tectonic forces could have had such radically different consequences on the Earth's outer shell remained unexplained. However, in books and papers over two decades Wegener contended that with his Pangaea-reconstruction (of the present continents) he could account for the prevailing geological, palaeoclimatic, and biogeographic problems at his time. But this was not in accord with reality, because his Pangaea faced serious problems from the very beginning.

Wegener's reconstruction was in many ways guided by wishful thinking – especially about geological 'adjustment' between the Atlantic continents. Although geology was far from his geophysical subjects, primarily meteorology and paleoclimate, he extracted information from the biological and geological literature which he believed supported his Pangea configuration, but the coastal similarity between Africa and South America seemingly overruled everything else. Thus, considering the geological match across the South Atlantic, Wegener (1929/66, p. 77) wrote: "It is just as if we were to refit the torn pieces of a newspaper by matching their edges and then check whether the lines of print run smoothly across. If they do, there is nothing left to conclude that the pieces were in fact joined in this way." This was a meaningless claim, because already two years before the last edition of his book was out, he had accepted du Toit's geological arguments (du Toit, 1927) that, due to the differences in metamorphic facies, the two continents must have initially been between 400-800 km apart (cf. Wegener, 1929/66, fig. 18). This distance estimate was only a punch in the air. For Wegener himself was surprised that northeastern Brazil, with reference to Keidel (1916), had a large-scale orthogonal fault pattern far into the continent (in Wegener, 1929/66, Fig. 17). **Fig. 21** shows du Toit's conception of the South Atlantic, prior to the supposed lateral drift between Africa and South America – together with Keidel's orthogonal fault system in NE Brazil.

Fig. 21 Because of great differences in metamorphic facies between the margins of South America and Africa, du Toit (1927) argued that an original distance of up to 800 km between them was necessary. On top of this geological correction, Keidel (1916) had mapped orthogonal coast-parallel fault zones at great distances from the coasts of NE Brazil –imitated in Wegener (1929/66, Fig. 17) and reproduced here as red-coloured dashed lines. A reasonable explanation would have been that the crustal belt between the two continents had been densified and isostatically subsided continental crust. Thus, the coastal similarity between Africa and South America could be given a completely new explanation.

It seems unlikely that an experienced and prominent field geologist like Alexander du Toit was unaware of the

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ubiquitous orthogonal fracture and fault network in the continental crust. He had also given geological reasons why, prior to the supposed lateral drift between the South Atlantic continents, there must have existed an elongated sea of sunken continental crust. So, on what geological basis could Alex du Toit limit the width of this intervening ocean? Tentatively, the opposing continents matched the shape of the equatorial Atlantic, so why couldn't the entire South Atlantic basement simply constitute assimilated and sunken continental crust? And Joseph Barrell's oceanization model (Barrel, 1927) supported such a possibility. Moreover, Wegener, based on du Toit's geological arguments, had obviously broken with his original isostasy-based opposition to the palaeontologists' 'land bridges' – of which there in late Mesozoic times had been several across the South Atlantic. This means that if the available geological information had been taken seriously, the major tectonic discussions in the interwar period could easily have taken a completely different course. Not least, by eliminating the idea of opening the South Atlantic, the Tethys belt would have retained its traditional form as an elongated endemic intracontinental seaway. Thus, Tethys would not have become a forced indentation of the Pacific Ocean with a fictitious Gondwana to the south. **Fig. 22 b** demonstrates Wegener's Pangaea with inferred Permo-Carboniferous glacial centres as had been reported in the early 1920s.

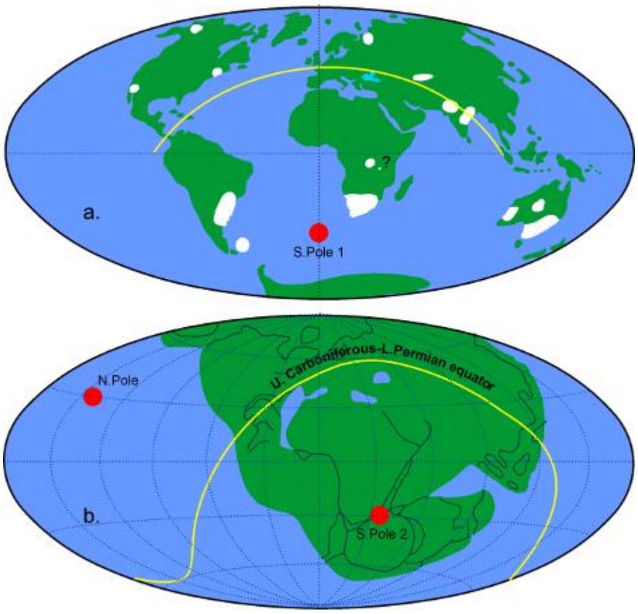

Fig. 22 Illustration a) shows Permo-Carboniferous glacial centres (white) as had been reported in the late 20s, dashed yellow curve represents Wegener's (1929) original Permian equator, and full dot (red) the corresponding S. pole 1. In Fig. b) the fossil-based sub-tropical Antarctica was placed in a postulated polar position (S. pole 2) which was contradictory. Fig b) is simplified after Köppen and Wegener (1924). By placing the fossil-based sub-tropical Antarctica in a postulated polar position (S. Pole 2) was contradictory.

Both Wegener and du Toit seem to have been so hung up on continental drift and the equatorial 'Atlantic fit', that alternative tectono-physiographic explanations were not taken seriously. But in the North Atlantic, Wegener encountered even greater geological obstacles and paleoclimatic contradictions. From his paleoclimatic analyses on the northern continents, the Lower Palaeozoic of North America had tropical conditions, while from the same analysis he had defined the phenomenon of true polar wandering in which the Lower Palaeozoic pole was in NW Africa. So, by closing of the North Atlantic, polar and tropical conditions were juxtaposed creating a climatic paradox. On the geological side, Wegener also encountered several insurmountable problems. He was well informed that since the 19th century continental and metamorphic rocks had been collected from seamounts between Iberia and the Azores. Moreover, it had long been known that the Azores islands contained a large and widespread selection of blocks of continental rocks that must have been torn loose and transported to the surface via volcanism, which thus formed the archipelago's top layer.

Based on this observation, Wegener proposed that the Azores Archipelago had a continental substratum which he guessed had a width of 1000 km or more. Just like du Toit's guess regarding a necessary pre-drift distance between the South Atlantic continents, of up to 800 km, Wegener also had no realistic reasons to limit the extent of the Azores massif. Wegener's Pangaea also did not have room for the Caribbean and the essential part of Central America. The many North Atlantic dilemmas were probably the starting point for Tuzo Wilson's proposal of an opening and closing history of the North Atlantic – the Wilson cycle (Wilson, 1966). This proposal has artificially removed all obstacles to crustal mobility – a practice that has so far been unstoppable. We are beginning to see how a highly dubious idea can develop in a way that trigger progressive ad hoc routines, eventually leading an entire science into disarray. However, Wegener based his Gondwana unification on two factors: the distribution of the Glossopteris flora and the spread-out of reported late Carboniferous-early Permian glacial activity.

Distribution of Glossopteris flora

Wegener had great difficulty explaining away the increasing fossil finds from Antarctica which indicated that the continent had experienced protracted tropical to sub-tropical conditions – not the icehouse climate that his Gondwana unification would imply. However, he considered the Permian Glossopteris flora as a characteristic vegetation of the southern continents which, according to his hypothesis, had been clustered around the late Carboniferous-early Permian South Pole. But in Wegener's time assemblages of this mire forest vegetation had also been reported from the northern continents – including areas that geographically were very distant from

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Wegener's south polar Gondwana (e.g. Lake, 1922). Later studies have strongly confirmed what was already known in Wegener's time, that in the Permo-Carboniferous of Antarctica the “growth was vigorous and annual increments were high…in sharp contrast to the narrow rings shown by trees growing today in high northern latitudes” (Thuswell, 1991 and references therein). Thus, in the Permian Coal Measures of East Antarctica, McLoughlin and Drinnan (1997) describe abundant Glossopteris fossils associated with 2-10 m thick coal beds containing remains of up to 60 cm thick logs. However, the relatively high growth rate in the Glossopteris Gully Member sequence, indicating at least warm temperate mire facies conditions, is according to the above authors extensively covered by tillite. This may suggest that the time in question was characterized by one or more interludes of global cooling. Ever since the early part of the 20th Century, fossil evidence has unveiled that Antarctica experienced tropical to warm temperate conditions throughout most of post-Precambrian time (cf. **Figs. 16 & 17**) – it was only Wegener's hypothetical reconstruction which required polar latitudes.

The classical Gondwana flora originates from the Damodar, Son-Mahanadi, and Pranhita-Godavari graben system of India. Basin sediments and glacier interpreted bolder beds are followed by coal measures within which the bulk of the Glossopteris flora occur – known as the Gondwana Supergroup. Goswami (2014) writes: “Glossopteris itself and most of the other members of this flora are believed to be of post glacial origin…The flora soon reached its climax under a damp and wet temperature climate in marshy environment. This is evident by its association with huge number of coal bed seams and the general absence of growth rings in petrified stem fossils within Lower Gondwana rocks”. Moreover, Maheshwari (1992), referring to similar leaves from the Permian of Siberia, writes: “I have examined these specimens, and had I not known from where these specimens had come, I would have unhesitatingly accepted their placement under the Gondwanan Gangamopteris and Glossopteris. However, hardly any paleobiogeographer accepts that these leaves are the same as the Gondwanan ones, probably because such an acceptance would not fit in with the concept of Continental Drift”. This again raises the question of the degree of subjectivity and wishful thinking in the geosciences, to satisfy today's plate tectonic speculations.

Strangely enough, during the reign of plate tectonics the Glossopteris flora has achieved iconic status through its purported strong link-up to Wegener’s Gondwana. However, the widespread occurrence of this group of humid forest vegetation, also on the northern continents, remains neither constrained nor understood (see debated fundamental issues by McLoughlin, 2011). Since there is no indication that the long-standing and unresolved Glossopteris debate is concluding, it is strange that even after today's vast amount of conflicting information, from all relevant geoscientific disciplines, hardly anyone seems ready to question Wegener's Gondwana/Pangea – the main source of today's problematic biogeographical situation. When purely technical and descriptive aspects are set aside, aren't we then facing science like any human enterprise – dominated by fads and urban legends created in the wake of certain opinion-forming dominant figures?

Observations of Glossopteris flora on the northern continents are increasing – including recent fossil sites in South Mongolia (Naugolnykh and Uranbiley, 2018) and NE China (Zhang et al., 2022). Though the Glossopteris flora is considered key evidence for the Gondwana configuration, various Glossopteris assemblages are widespread in the Northern Hemisphere – described as Angaran, Euramerican and Cathaysian provinces, though without sharp boundaries (McLoughlin, 2011). Also, in the Gondwana continents, “one distribution pattern shows mixed floras along the marginal basins of the Tethyan region during the middle and late Permian. Another pattern is evident in the Gondwana floras where Glossopteris contain several extra-Gondwanic elements” (Srivastava and Agnihotri, 2010). This indicates an intermixing of the various flora elements between the hemispheres. However, the plate tectonic gathering of all continental mass, in the form of a wide wedge-shaped sea that gaped eastwards, has led to persistent controversies – about geographical distribution, origin, environmental conditions, and not least whether this humid forest vegetation really grew under polar conditions (in Wegener’s Gondwana). Since India is considered the main centre of the Glossopteris flora, it is not unreasonable to think that this flora originated in the Northern Hemisphere – and thus is not a characteristic feature of Wegener's constructed Permian South Polar region.

In this unclear situation, Krassilov (2000) has presented a Permian Glossopteris geography and climate zonation in which the northern continents play a much more prominent role, than one gets impression from in the Gondwana-inspired literature. Krassilov depicts the mid-Permian plant geography for which Eurasia, southern North America and the Tethyan belt represents by far the largest number of reference sites. He writes: “The Tethyan phytogeographic realm is a continuous zone of mixed Cathaysian and Gondwana floras extending from southern Spain and Morocco over the Middle East, Anatolia and North Africa….to Tibet, Yunnan, Thailand (Phetchabun), Sumatra (Jambi) and West New Guinea (Irian Jaya). Ecological equivalents of the Southern Cathaysian vegetation might occur on the Gulf Coast and over Caribbean. Occasional reports of gigantopterids come from Mexico and Venezuela”.

In this context, Tuzo Wilson’s (1954) suggestion that the epicontinental Tethys had been a surface expression of another deep faulted Benioff Zone (forming a great circle around the globe nearly perpendicular to the circum-Pacific belt), which during the Mesozoic advanced to the Caribbean (Aubouin et al., 1977), seems realistic. The depositional conditions were governed by stagnant waters with development of faunal endemism (Hallam, 1977) – supporting the classic concept of Tethys as a shallow intracontinental sea, which during the Mesozoic crossed the present Central Atlantic (**Fig. 1**). The westward extension of the Mesozoic Tethys, as a shallow stagnant and endemic seaway, is in perfect agreement with the unusually high concentration of Middle Cretaceous black bituminous mudstone/marlstone deposits in the European Tethys and the Central Atlantic, as demonstrated in the black shale world map of Ohkouchi et al. (2015). According to Sonnenfeld (1981, and contributions therein), the Mesozoic was apparently the principal period in the history of the Tethys. Therefore, the seaway was unlikely to be a significant barrier to late Paleozoic plant migration. As a continuation of this reasoning, Krassilov (2000) argued that the Permian Euramerican-Cathamerican-Gondwana Glossopteris mixing is incompatible with the view of Tethys as a wide oceanic indentation of the Pacific and with "a radical reassembly of the continents" – which dominate todays Earth sciences.

Late Carboniferous-early Permian Ice Age

Wegener's evaluation of the palaeoclimatic system was based on abundant fossil and rock evidence from the northern continents, from which his global polar wander path had been established. On this dynamic platform, the late Carboniferous-Permian geographic South Pole was located a little southwest of South Africa (**Fig. 22a**), consistent with the geologic evidence of South Africa being the major ice centre on Earth at the time. However, Wegener's well-established polar wander path conflicted with his idea of uniting the southern continents and India, and to achieve an 'acceptable' continental assembly, the Permian South Pole was conveniently placed east of South Africa (see Fig. 22b). The continents were wriggled into place. The protracted tropical to sub-tropical climate in Antarctica was explained away as a decisive problem. Similarly, he explained away reported late Palaeozoic glacial events in North America, Central Asia and NW Russia (Coleman, 1925, 1926).

It is strange that a palaeoclimatologist like Wegener did not consider the wide-reaching effect of global cooling events. Thus, large Pleistocene icefields covered larger parts of northern Europe and North America, but southern Australia was also repeatedly glaciated during the Pleistocene (Colhoun and Barrows, 2011), in a region which normally experience subtropical to warm intermediate latitude conditions. Except for a shorter interval of the late Carboniferous, Australia had palaeoequatorial climate throughout the Palaeozoic (Spjældnes, 1961; Schwartzback, 1963; Lowenstam, 1963; Brown et al. 1968; Trewin and McNamara, 1994; Gouramanis and McLoughlin, 2016). However, The Carboniferous–Permian transition was Earth's last pre-Pleistocene icehouse–greenhouse transition, recording major disturbances in late Palaeozoic latitude-defined climate regimes (Fielding et al., 2008; Myers, 2016; Pardo et al. 2019).

In a review of Permian-Carboniferous glacial signatures in the Canning and southern Carnarvon basins, Mory et al. (2008) argue that "Widely distributed glacially derived material indicates that an extensive ice sheet covered Western Australia …, although definitive glacial characteristics are less well defined". Their reservations are clearly described by a basin-wide glacially influenced strata, but more direct evidence of glaciation – such as striations in basement and sandstone, are few and localized. While the lowermost (Upper Carboniferous) sequence represents a glacial diamictite-mudstone-sandstone facies association, the middle and upper sedimentary package (early Permian) is described as deltaic – and as coal-bearing. This indicates a marked shift in environmental conditions – from cool in topmost Carboniferous to warm/hot in early Permian. A similar drastic temperature rise – from cold water to (sub)tropical states was found by palaeotemperature studies by Lowenstam (1964). Although Australia in the late Palaeozoic undoubtedly had glacial activity, its extent is very unclear. Thus, Fielding et al., 2008, reporting stratigraphic and sedimentological data from eastern Australia, suggest that the late Palaeozoic Ice Age there comprised at least eight discrete glacial periods of relatively short duration, separated by non-glacial intervals of comparable duration (up to a few million years). Under such circumstances, it seems unlikely that it was possible to build up a large ice sheet. In addition, authors like Eyles and Brockert (2001) questioned the primary glacial character of several glacial deposits, noting the high degree of modification by sedimentation processes. Most likely Australia had only a few minor ice cores (Brown et al., 1968) from which glacially derived material was dispersed. That is, the conclusion of Mory et al. (2008) that "an extensive ice sheet covered Western Australia" seems questionable.

It is presently assumed that the Upper Carboniferous-earliest Permian probably was the most prolonged icehouse interval in Earth's history, consisting of relatively short glacial events, interrupted by warmer periods. Along with this extended glacial-interglacial oscillation, the cycles were marked by coincident fluctuations in the terrestrial biosphere and environmental conditions – as exemplified by the palaeoclimatic record of southern South America (Limarino et al., 2014 and references therein). In the upper Middle Carboniferous, the glacial stage affected all basins of southern South America. During its terminal phase it disappeared first in the western basins (i.e. in regions that had the largest distance to the Upper Carboniferous-Permian South Pole – **Fig. 22a**), and thereafter in the

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eastern basins (Paraná). Post-glacial climatic improvement took place in earliest Permian when glacial deposits disappeared in South America, and the terminal icehouse stage was followed by thick coal layers in the Paraná basin. The Permian climate eventually developed into extreme greenhouse conditions with semiarid or arid conditions over much of South America.

In North America, Wegener had very few sympathizers, but an international meeting on his hypothesis was organized in 1926. The conference papers which were published 2 years later by Am. Assoc. Petrol. Geologists contain very little of in-depth arguments, and again the sensational and crucial fossil flora finds from Antarctica was barely mentioned. The conference participants were primarily concerned with a few 'Permian' glacial deposits reported from locations in North America. In his contribution to the published conference volume, Wegener (1928) maintained that these observations must be due to misunderstandings, because in Permian times the continent had been characterized by equatorial to sub-equatorial conditions; he seemed to have forgotten that during the last ice age the edge of the ice cover reached to the southern US states. But he nevertheless admitted that if the interpretation of at least some of the observations, notably the Squantum 'Tillite' (Boston Bay Group), should turn out to be correct, this would be a serious attack on his Pangaea model. The Squantum conglomerate, regarded as the best example of late Palaeozoic glaciation in North America (Schwartzback, 1963), is supported by its extremely poor sorting and heterogeneity of the conglomerates, lack of stratification, and, and striated rocks. The only fossil evidence to confirm the age is two poorly preserved tree trunks which constrains the age to between Devonian and Permian (Rehmer and Hepburn, 1974; Rehmer and Roy, 1976 and references therein). Zircon dates which suggest terminal Neoproterozoic ages of Squantum pebbles (e. g., Thompson and Bowring, 2000) can of course be interpreted as source rocks from the surroundings.

India – the final nail in the Gondwana coffin?

It is regrettable that Wegener, who provided a factual account of the palaeoclimate evolution of the northern continents, including the establishment of the global polar migration path, fell victim to wishful thinking and selective handling of data from the southern hemisphere. Based on his global polar migration path and latitude associated climate system (**Fig.16**), the Permian equator ran across Central Europe with a South Pole located slightly southwest of South Africa. This made it natural that South Africa was the main glacial centre at the time. Also, if we leave the southern continents where they are and extend Wegener's Palaeozoic palaeoequators (Fig. 16) around the Earth, both Australia and Antarctica get palaeoequatorial latitudes. Apart from the now well-established late Carboniferous-early Permian glacial interlude, the fossil evidence from these continents is in good agreement with Wegener's climate system, both Australia and Antarctica get palaeoequatorial latitudes – a fact he ignored. Instead, he began to manipulate the southern palaeogeography, and for reasons of adaptation, he shifted his Permian South Pole next to eastern South Africa, adjacent to Antarctica (**Fig. 22b**). This was a pointless relocation, because Antarctica had experienced a long prehistory with warm climate – completely different from the icehouse condition his reconfiguration required. With respect to palaeoclimate, Antarctica was therefore a large "black hole" in his Gondwana unification.

As with the other land masses, India has not undergone lateral migration; during the Upper Cretaceous to Palaeocene, India was exposed to inertial rotation in situ (Storetvedt, 1990, 2003/23). During the onset of this event, India was wedged between the fault-related Tethys Basin and the northern part of the N-S oriented Central Indian shear zone – located between the Laccadive-Chagos and 90 E ridges. This exposed position made India strongly predisposed to tectonic instability. The resulting clockwise rotation expectedly caused significant tectonic shear reactivation along the boundary zones (behaving like a twisted deck of cards) down to a diffusely defined base. The tectonic torsion reactivated the fracture spacing in the affected lithosphere, thereby paving the way for increased fluid infiltration from below. In addition, India's rotation provided an opening for magma to the Deccan complex as well as injection of ophiolites to the bordering Tethys Basin. The resulting seismic effect was lower velocities in the border regions – as well as a presumed diffuse transition towards the higher velocities of a tectonically less affected central core. Therefore, wider areas of the Indian block would be expected to show reduced seismic velocities, while a central core of higher velocities would taper downward towards the "bottom" of the mobile mega block. P-wave tomography studies by Kennett and Widiyantoro (1999) produced upper mantle velocity images that agree well with these predictions. In this rotation process, the thin oceanic crust south of India has been extensively fractured, paving the way for hydrous fluid-induced granulite-eclogite metamorphism (Austrheim, 1987; Leech, 2001; Putnis and Austrheim, 2010). This has led to gravity-driven crustal delamination – from below upwards, which is the likely explanation for the extremely low gravity geoid "hole" just south of India.

If the low velocity 'collar' circumscribing the Indian craton represents a lithospheric crush zone, it can be assumed that the oceanic embayments surrounding India – Bay of Bengal and Arabian Sea, originally were parts of a Greater India. By inference, it follows that the two deep-sea regions began to form shortly after the tectonic rotation had ceased – presumably in the early Palaeocene, a prediction that is borne out by a range of geophysical and geological facts (cf. Storetvedt, 2003/23, p. 267-279). Thus, the

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curvilinear Owen Fracture Zone (OFZ) seems to represent the most prominent western tectonic boundary of the clockwise rotation of Greater India – producing the left-lateral shearing of the OFZ. Along the eastern coast of Arabia, also the quasi-continental Owen Basin shows clear signs of having participated in this tectonic rotation (cf. Whitmarsh, 1979).

Fig. 23 gives a colour-shaded relief map of the Himalaya-North India including a sketch of the GPS velocity pattern. This illustration shows the tectono-topographic features around India's northern flank which represents a regionally strongly bent and seismically active shear belt. From eastern Pakistan it continues as a highly tectonized Himalayan Tethys, which, due to India's rotation, widens to the east, before the deformed intracontinental Tethys belt turns sharply to SE-SSE. The broad crust-cutting belt naturally have been of utmost importance for the supply of supercritical fluids from the mantle and the associated uplift of the Tibetan Plateau and its flanking mountain ranges, at the end of the Miocene (Storetvedt, 2003/23, 2015; Michaelsen and Storetvedt, 2023 and references therein). With respect to Eurasia, the GPS velocity image of the India-Himalaya region (Zhang et al., 2004; Taylor and Yin, 2009: Bisht et al., 2020), originally spurred by India's in situ clockwise motion at around the K/T boundary, shows that this wrench rotation is still ongoing. Because of India's rotation, with associated shearing in the Himalaya region, significant Moho jumps can be expected to occur across prominent fault zones – just as for other prominent crustal discontinuities along the Alpine/Tethys belt (e.g., Daigniers, 1982). Thus, Yue et al. (2012) found a 20 km Moho offset beneath the northern edge of the Kunlun Mountains, and a 10 km Moho jump beneath the Jinsha River fracture zone; that is, crustal section within the Tethyan belt with different degrees of crustal thinning have been juxtaposed.

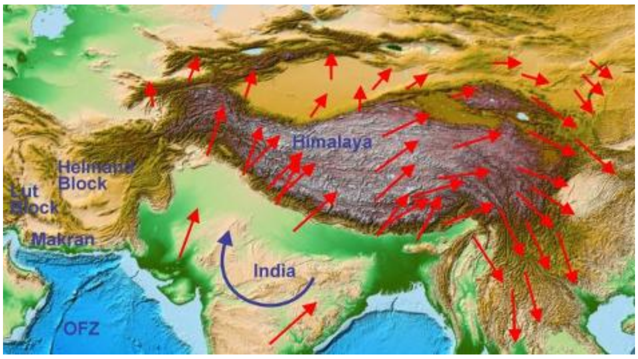

Fig. 23 Colour-shaded relief map of Himalaya-North India from noaa_world_topo_bathymetric_lg.jpg
GPS velocity directions are shown by red arrows (see text for references). Note how the GPS pattern and the curved tectonic zones of eastern Pakistan and north-eastern India/western Myanmar fit into the major clockwise rotation of Greater India (Storetvedt, 2003/23, p. 265-272). This rotation also has produced the prominent shear tectonics of Himalaya Tethys.

In the Precambrian, the elongated and probably world-encircling deep-fracture-related Tethys (cf. Wilson, 1954) most likely had minimal water and therefore no major topographical depressions either. On a flat or slightly undulating land surface, the first major water pulse was outgassed in the Lower Palaeozoic, with maximum transgression in the Upper Ordovician (**Fig. 24**). This means that in the early Palaeozoic the amount of surface water was moderate and unevenly distributed, but with such surface conditions it would be possible to correlate the Cambrian fauna of North India (Tethyan Lesser Himalaya) in a wider context. It is not surprising therefore that the tropical Cambrian marine biota of northern India is closely related to those of North and South China. Moreover, “Links with Australia are suggested by non-cosmopolitan species, but Indian biotas share less in common with Australia than with parts of China” (Hughes, 2016) – suggesting a close Lower Palaeozoic marine fauna link between India and Asia.

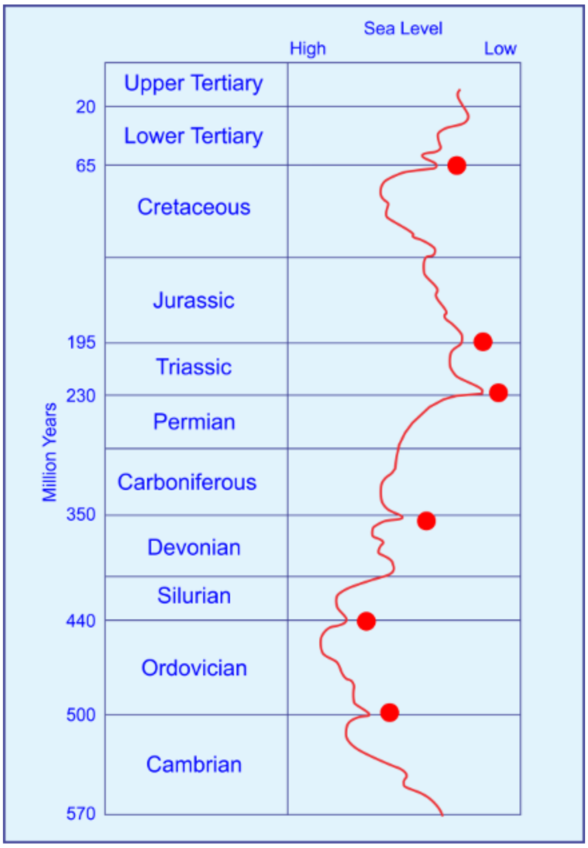

Fig. 24 Generalized sea-level curve for the Phanerozoic where full circles mark the six most important marine extinction events. Based on Hallam (1992). Note that the biotic catastrophes correspond to times of sea-level minima and related major geologic boundaries – demonstrating the dynamo-tectonic pulsation of the degassing Earth.

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During the Middle and Upper Palaeozoic, the shallow epicontinental seas gradually retreated from an increasingly dry land surface – a development that culminated in a deep sea-level regression at around the Permian-Triassic transition. The still limited amount of surface water had drained into embryonic depressions, areas which at an accelerating rate towards the Upper Cretaceous, and with a major supply of surface water, became present-day deep oceans. With the ever-increasing land surface during the Permian, together with many unassimilated continental ridges and plateaus, the conditions were well suited for global spread of the glossopteris flora – from its possible origin in India, including a general distribution of flora and land fauna. With the varying evolution of Tethyan physiography, because of dynamo-tectonic sea-level variation and related crustal fluctuations, the generally shallow Tethys would time and again have formed migration corridors between India and the rest of the globe. Thus, the late Devonian to early Carboniferous India, is correlated with coeval records worldwide (Gupta et al., 2023).

Another important observation is the late Carboniferous flora of Kashmir Himalaya, India, is thought to have grown in warm climate and thus immediately before the Carboniferous-Permian Ice Age (Singh et al., 2013). This observation is another indication that the late Palaeozoic Ice Age was only a global cooling event – and thus unrelated to Wegener's hypothetical Gondwana. After the major regression at around the P-T boundary, the sea-level continued to be relatively low in the early Mesozoic and thus it is likely that biological migration routes between India and Asia existed, at the same time as isthmian links to Africa, via Madagascar, and on to South America also was intact (see below). This would imply that India, which according to recent studies (Bajpai et al., 2023; Khosla and Lucas, 2024) was a main centre for neo-sauropod development, also had good dispersal possibilities. But during Upper Cretaceous-Palaeocene, when global wrench tectonics had its climax – most transoceanic land connections were broken and assimilated by upper mantle processes. Thus, a terrestrial migration corridor from India to South America, via Africa, had been closed.

During the Jurassic-Upper Cretaceous, the Earth's upper mantle underwent another major increase in hydrostatic build-up, which raised the oceanic crust – at the same time as the evolving oceanic crust underwent accelerated thinning. This was also the origin of the Cenomanian sea-level rise (Fig. 24), as well as the associated discharge of a major part of today's surface water. Further, the related dynamo-tectonic processes led to structural upheavals along the intracontinental Tethys. During the Palaeocene, most of the western Tethys had thus become lowland – a drainage effect that increased eastward (Sonnenfeld, 1981), including topographical effects resulting from India's rotation. This means that India, at least from the Cenomanian-Palaeocene onwards, must have had open migration routes for land fauna to Eurasia, further on to Africa, and presumably also to South America via a periodically still existing equatorial land connection (discussed above).

The tectonic rupture of Laccadive-Chagos Ridge, Mascarene Ridge, Seychelles Bank, along with the complex submarine bathymetry of North Madagascar-East Africa passage (cf. Sandwell et al., 2014), can be seen as a tectonically split and submerged former continental connection between India and Africa via Madagascar. A direct exposure of this crustal history is demonstrated in the shallow Seychelles archipelago which has a Moho depth of 33 km (Matthews and Davies, 1966), and that 25 out of 100 islands have exposed granitic rocks (Ashwal et al., 2002). The final break-up and thinning of the original continental connection between India and Africa can be assumed to have been accelerated by the extremely sheared Carlberg/Central Indian Ridge. From the evidence at ha, India has always been part of Asia. So, the lack of endemism in Indian terrestrial tetrapods during the Mesozoic (Khosla and Bajpai, 2021 and references therein) is only a plate tectonic Gondwana conundrum. Thus, “On the contrary, Indian Mesozoic and Tertiary vertebrates show closest similarities to those of Laurasia, indicating that India was never far from Asia. The correlation of faunal similarity is extremely poor between India-Antarctica and India-Australia. This suggests that India cannot be placed alongside Antarctica or Australia in a pre-drift assembly” (Chatterjee and Hotton III, 1986). Therefore, if we set aside the unconfirmed plate tectonics/Gondwana epidemic, and take the available rock, geophysical and structural evidence from the oceans at their face value, then the missing terrestrial link between India to Australia and Antarctica can easily be explained by a progressively submersed Indian Ocean during the Mesozoic.

An example of the prevailing confusion is the clay mineral palygorskite which is widespread in drilled sites of DSDP Leg 25 in the western Indian Ocean – including the last joint in the pre-drift biological land bridge between India and Africa. Palygorskite which has been reported from various sedimentary environments – subtidal, lacustrine and deep marine (e.g. Ryan et al., 2019; Botha and Hughes, 1992; Vallier, 1974; Peterson, 1972), is generally considered to have formed under warm alkaline and evaporative conditions. Thiry and Pletsch (2011) attempted to partially solve this problem, while at the same time an unlikely paleoclimate problem arose. They argued that in some marine deposits “palygorskite clay was formed on adjacent continents and was subsequently transported to the deposition site. However, microstructural and mineralogical evidence suggest that the purest deposits were formed in situ on the seafloor in the case of the middle Cretaceous to lower Eocene”. From marine occurrences, the authors speculate whether climatic conditions in the Upper

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Cretaceous were so extreme that palygorskite could form even in deep sea. But this is only an auxiliary proposition to satisfy the seafloor spreading model. On the contrary, during the period in question, the DSDP Leg 25 drilling localities were in warm subtropical latitudes, while epi-continental parts of the western Indian Ocean (as well as of other deep-sea areas) were undergoing accelerated crustal oceanization and subsidence. Therefore, the palygorskite deposits in Leg 25 drilling sites are likely to have formed under warm littoral or shallow water evaporative dolomite conditions (e.g. Peterson et al., 1972; Ryan et al., 2019) – which makes the invocation of extreme climate conditions non-pertinent.

A similar example of crustal subsidence of original subaerial and shallow water conditions is exposed in the shelf-margin-deep ocean development off NW Africa (Storetvedt, 1987). Data from petroleum exploration wells and offshore seismic lines (Querol,1966; Martinis and Visintin, 1966; Ranke et al., 1982) suggest that the Mesozoic sedimentary succession is distributed in a 'down-to-basin' flexuring and normal fault pattern paralleling the coast and related to seaward subsidence. Beneath the shelf and upper slope, the Mesozoic sedimentary pile may show thicknesses up to 15 km or more, but further seaward the basement depth and sediment distribution become increasingly obscure. However, DSDP sites 544-547 on the Mazagan Plateau off Morocco, at water depths of c. 4000 m, encountered Lower Mesozoic shallow water to subaerial sediments – including halite and red sediments, overlying a basement of gneiss. Furthermore, geophysical modelling of the faulted NW African margin suggests that the continental crust has thinned by about 20 km (Hinz et al., 1982 a and b). A compilation of relevant information from DSDP-IPOD sites off NW Africa (nos. 12, 139-141, 369, 370, 397, 415, 416, 544-547) concur with this conclusion. Thus, Storetvedt (1987) found that the combination of evaporite and palygorskite clay, in offshore basins in water depths up to 4000 m and more, support the geophysical conclusions as well as the more direct DSDP/IPOD evidence from the Mazagan Plateau. That is, the crystalline basement along the NW African margin is thinned continental crust, having developed largely during the Cretaceous.

In the Lower Palaeozoic, the Earth's surface received the first significant discharge of indigenous water, with sea level high in the Upper Ordovician. The featureless surface was covered by a shallow and almost pan-global epicontinental sea associated with an explosion of higher forms of cosmopolitan marine life (cf. Boucot and Johnson, 1973). This early Palaeozoic release of a fraction of the globe's internal water probably took place through a) the deep Benioff Zone circumscribing the Pacific and b) through the corresponding deep fracture zone seaward of the Indonesian island arc – with probable continuation along the epicontinental Tethys (Tuzo Wilson, 1954). Despite this early Palaeozoic expulsion of virgin seawater, the accumulated gas/liquid pressure in the Earth's outer layers counteracted the inward gravitational pressure – to such an extent that fracture populations installed in late Archaean time became increasingly open with depth. In this way, the continental crust of the perpetually degassing Earth has acquired circulating aqueous solutions with a selection of entrained elements from the interior. This principle has been well confirmed by the deep boreholes of Kola and KTB, Germany. The Earth's progressive outgassing has led to periodic changes of its moment of inertia, which explains why the globe has acquired its pulse-like geological history. The dynamic changes have turned the Earth into a kind of hydraulic pumping machine, and due to the confirmed fluid permeability of the continental crust, there will naturally be an interaction between continental and oceanic basin development – the same degassing effects that have formed the oceanic crust will also have affected the continental crust, albeit to a far more moderate degree. The generalized sea level curve, displaying the transgressive-regressive cyclicity (Fig. 24), reflects the combined seawater history and episodic crustal/basin development. These surface processes have been triggered by dynamic changes caused by progressive regulation of internal mass and thus the rotational properties. These physical changes have resulted in events of spatial shifts of the Earth's body (true polar wander), and of spin velocity (**Fig 25**). These dynamic variations are here regarded the very engine behind Earth's pulsating history, where the important geological time boundaries represent marked changes of the planet's moment of inertia.

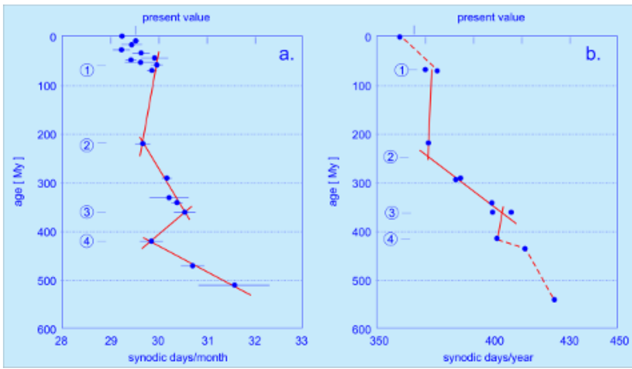

Fig. 25 a) Compilation of presumed days per month and b) presumed days per year, based on growth rings in fossil shells. Simplified after Creer (1975).

Closing reflections

In this essay I have argued that the deep-sea crust is thinned and petrologically transformed original continental crust – a process that is driven by Earth's eternal struggle to attain internal thermo-chemical equilibrium. Degassing of lighter elements from the core (by whatever mechanism) has apparently been going on since the dawn of the planet, but irregular degassing, both spatially and regarding volatile content, has apparently led to today's uneven crustal

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structure. Around the Permian-Triassic boundary, delamination of the lower crust, with associated isostatic basin subsidence, made a certain leap ahead. But according to deep sea drilling data (Ruditch, 1990), the development of the deep-sea basins is primarily a Middle-Upper Cretaceous phenomenon, and in the Palaeocene, the essential part of today's deep oceans had come into place. Thus, the typical oceanic crust is only c. 100 million years old – a crustal type that has never before existed. However, both continental and oceanic crust have very variable thicknesses, and as we have seen above, there is often a smooth transition between them. These realities have not previously been explained, but they fit easily into the new Earth degassing theory outlined in this essay. This means that in recent geological time the originally pan-global continental crust has been subject to extensive petrological/gravitative transformation processes. On this background, today's land masses are moderately delaminated/transformed parts of the original crust. But satellite images of the seafloor show a multitude of more strongly assimilated continental remnants – in the form of submerged aseismic ridges and plateaus, and their ancient origins are often substantiated by recovered ancient and metamorphic rocks.

The delayed crustal development has been confirmed by deep-sea drilling since the late 1960s. However, the plate tectonic world view has completely ignored this important information – while speculatively asserting that in the past thin oceanic crust has come and gone. Under the auspices of the so-called Wilson-cycle, even Precambrian continental blocks are allowed to move without physical obstacles, even though explanations are overloaded with ad hoc inventions. On top of that, the basic assumptions of plate tectonics have remained wandering conundrums, and all vital questions in geology are as unsettled as ever. What has plate tectonics done to the well-established deep continental mantle roots? In the grip of plate tectonics, the Earth's history has become increasingly incoherent and completely incomprehensible. It is therefore not in the least surprising that the two leading figures towards the plate tectonic revolution, Stanley Keith Runcorn and John Tuzo Wilson, in their older and presumably wiser days, wrote off plate tectonics, maintaining that a completely new mobilist understanding of the Earth was needed.

For a new geoscientific revolution, we already have all the key facts required – we just need open-minded and fearless scientists who dare to come forward to expose the failure of the fundamental tenets of the plate tectonic creed. The geophysical and geological literature is replete with important data awaiting an integrative theoretical structure with predictive capacity. As I have outlined in this essay, in the first half of the 20th century several important tectonic proposals were launched without receiving significant attention. Only Wegener's hypothesis of continental drift received sustained attention – primarily because it deviated so strongly from traditional thinking and thus had a certain entertainment value. Human nature was obviously at play from the very beginning.

Regarding basin formation, for now we only have relevant information about the upper, but obviously the dominant, sedimentary layers of the deep-sea basins, a situation that is completely different for the continents. For example, the interior of North America – including the Hudson, Williston, Michigan and Illinois basins, constitutes a tectonically relatively stable cratonic crust that in regions have developed relatively shallow depressions housing post-Precambrian deposits – primarily from the Lower and Middle Palaeozoic. Under the auspices of plate tectonics, the origin and development of these depressions have remained controversial and unclarified (e.g. Sloss, 1963; Howell and Pluijm, 1990; Klein, 1991; Stevens Goddard et al., 2023; Armitage and Allen, 2010). Among various proposals, it has been suggested that the Michigan and Williston depressions have been subjected to fluid-triggered upper-middle crustal elasticity in combination with density increase by eclogitization (Haxby et al., 1976; Fowler and Nisbet, 1985).

With a fracture population filled with hot hydrous fluids, resulting in elastic crustal columns, would be a favourable starting point for isostatic subsidence and basin formation, and eventually lead to advanced crustal oceanization. Within the conterminous North America, only the western basins – Powder River and Williston basins of Wyoming and North Dakota, have accumulations beyond late Middle Palaeozoic (Peterson and MacCary, 1987). Quite unlike the midcontinent examples, the western sedimentary depressions are dominated by Cretaceous deposits. The likely cause of this extended basin development is that North America during the late Mesozoic was thrust over the regional Benioff Zone (cf. Fig.2). This led to new supply of hydrous fluids to the western crust, with attendant eclogitization, gravitative delamination, and accelerating basin subsidence as related results. The relatively stable cratonic mid-continental USA, on the other hand, shows large Moho variations – varying between 28 and 57 km (Xiao et al., 2022). This indicates that the dynamo-tectonic fluid-driven crustal thinning did not have a post-Palaeozoic development in this region (cf. Klein, 1991) – consistent with the tectonic quiescence of the Appalachian fold belt. The ups and downs in Moho depth, resulting from the Xiao et al. study, can be ascribed to a combination of delaminated and non-detached eclogitized uppermost mantle and lower crust. Owing to the accelerated crustal oceanization in Lower and Middle Cretaceous, the evolving deep-sea basins underwent stages of stagnant euxinic conditions – a global feature of isolated Lower-Middle Cretaceous basins (cf. Jenkyns, 1980; Arthur and Sageman, 1994; Wilson and Norris, 2001), which however had a concentration in western European Tethys and its extended Central Atlantic branch (cf. Jarvis et al., 2011; Ohkouchi et al., 2015). These

ISSN number; ISSN 2202-0039

observations are consistent with the traditional (pre-plate tectonic) epicontinental Tethys (**Fig. 1**). Thus, the pre-Cenomanian isolated and anoxic condition of the western Tethys gave rise to organic-rich black shale deposits, but due to accelerating oceanization of the Atlantic crust, the stagnant conditions of the early central Atlantic were replaced by sedimentation under well-oxygenated conditions.

It is strange that the fundamental problems faced by Wegener's hypothesis, especially in the Southern Hemisphere, have never been openly discussed and scientifically acknowledged, even though critical palaeoclimatic and other pressing problems were already evident in his time. Where were the biogeographers when the fossil record from Antarctica gave strong evidence that the continent had had a several hundred-million-year prehistory of tropical to sub-tropical conditions – not that ice-house climate which his Gondwana construction entailed? And further, how could Wegener and other biogeographers avoid seeing that the two polar regions had experienced similar climate histories? Was it the present south polar ice cap that stood in the way of their field of vision? In any case, we now need a new scientific attitude away from the non-productive plate tectonic urban legend – an open-minded shift in mentality that can promote lasting influence on the creative development of students and young researchers.

Acknowledgement

This essay is not in ethical conflict with anyone . My special thanks go to the editor for his careful review and useful comments . My thanks also go to Frank Cleveland and Rune Storetvedt for their continued technical assistance – help I could not have done without.

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NCGT Journal
New Concepts in Global Tectonics

New Concepts in Global Tectonics Journal
Volume 14, Number 3, March 2026

ISSN number; ISSN 2202-0039

The Miyake-Hawthorne Consilience: A Unifying Forensic Reconstruction of Global Plasma Catastrophes (5259 BCE & 663 BCE)

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Abstract: This paper establishes a unified forensic model for reconstructing prehistoric solar-plasma cataclysms through Four Pillars of Consilience: Dendrochronology, Glaciology, Historical Mythology, and Artistic Iconography. We demonstrate that the 5259 BCE and 663 BCE "Yatagarasu Miyake Event" are absolute chronological markers synchronizing the Dispilio Tablet (Greece), the Yayoi Pillars (Japan), and the Nihon Shoki's Chronology. We analyze the Nihon Shoki's account of the Yatagarasu (the celestial guide) and the Golden Kite—a specific solar plasma burst resembling a luminous bird with spread wings—as high-fidelity eyewitness records of the August 18th 664 - January 17th 663 BCE transition. We conclude that the "Blood Sky" depicted in Yangshao, Yayoi, and Meiji-era artwork (Yoshitoshi, Chikanobu) serves as a diagnostic 630.0 nm filter for these events which correlate with Assyrian records that are some of the first accounts of red skies, supported by a triple-layer protocol of falsifiable predictions for Yangshao amphoras and Banpo wood piles.

Keywords: Absolute Dating, Archeoastronomy, Ancient Iconography, Consilience, Dendrochronology, Miyake Event, Solar Particle Event (SPE), The Miyake-Hawthorne Consilience, Yatagarasu Miyake Event of 663 BCE

Introduction

For millennia, humanity has looked to the heavens with both reverence and terror, recording celestial phenomena that modern science long dismissed as mere allegory. However, recent breakthroughs in Miyake event research—extreme solar particle events (SPEs) that leave permanent radioactive scars in tree rings and ice cores—are forcing a radical reassessment of our ancient records. We are discovering that the "celestial birds" of antiquity, such as the Yatagarasu and the Golden Kite, were not products of imagination, but precise forensic logs of a sun capable of catastrophic outbursts. This paper argues that two specific events—one in the 53rd century BCE and another in the 7th century BCE—provided the visual template for global mythology and iconography. By bridging the gap between the hard data of geophysics and the vivid witness accounts of the *Nihon Shoki* and Assyrian tablets, we can reconstruct the Earth's environmental history with unprecedented accuracy.

The universal "Blood Sky" and "Sun Crow" motifs of antiquity are forensic records of catastrophic solar proton events. This Miyake-Hawthorne Consilience proves that the 5259 BCE event created the primary visual "alphabet," and the 663 BCE Yatagarasu Miyake Event served as the catastrophic "re-reading," validating ancient historical texts and artistic artifacts as primary scientific data for reconstructing the Earth's environmental history.

The Four Pillars of Consilience (Means & Methods)

Pillar 1: Dendrochronology (The Temporal Anchor)
The 5259 BCE Event (Dispilio):

The empirical method of "anchor-point dating" uses sudden, global spikes in Carbon-14—known as Miyake events—to provide absolute precision for archaeological and geological sites. Because these solar blasts leave a simultaneous "mark" in the tree rings of every living tree on Earth, finding a spike in a wooden artifact is like finding a digital date stamp.

Researchers have used several distinct radiation spikes to fix the timelines of these four major sites with absolute calendar-year certainty:

- Dispilio, Greece (5259 BCE Event): In Nature Communications (2024), Maczkowski et al. (**Fig. 1**) used the 5259 BCE spike to anchor the European Neolithic timeline. By identifying this mark in wood piles, they established a fixed, calendar-year anchor for regional chronologies that were previously based on estimates. Notably, while many popularized images of the "Dispilio Tablet" are replicas, for the sake of academic accuracy, the primary authoritative image of the artifact is found in the Facorellis paper (Facorellis et al., 2016).

NCGT Journal
New Concepts in Global Tectonics
New Concepts in Global Tectonics Journal
Volume 14, Number 3, March 2026
ISSN number; ISSN 2202-0039

Fig. 1 Dispilio Site Maps (Maczkowski et al., 2024)

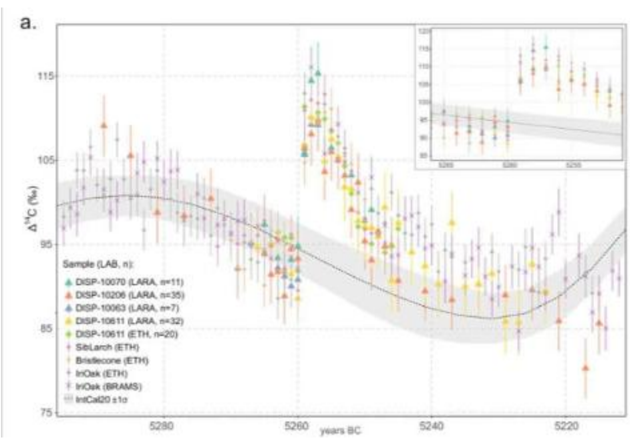

Fig. 2 Chart of 14C spike of 5259 BCE (Maczkowski et al., 2024)

- L' Anse aux Meadows, Canada (993 CE Event): In a landmark study published in Nature (2021), Kuitems et al. definitively dated the Viking presence in the Americas to the year 1021 CE. By identifying the 993 CE Miyake event in wooden artifacts found at the site, the team was able to count the subsequent annual rings to the bark, proving exactly when the trees were felled by European settlers.
- Mount Paektu/Baitoushan (774 CE Event): Published in Radiocarbon (2017), Hakozaki et al. verified the annual dating of the massive 10th-century eruption. By utilizing the AD 774–775 radiocarbon spike (the Miyake event) as a precise temporal anchor within fossilized trees, researchers pinpointed the "Millennium Eruption" to late 946 CE, reconciling the geological data with historical records.
- Puget Sound, USA (774 CE Event): In Science Advances (2023), Black et al. utilized the 774 CE Miyake event to reveal a massive multi-fault earthquake threat for the Seattle metropolitan region. By cross-referencing mass tree mortality with this specific radiation spike, the study proved that two major faults—Seattle and Tacoma—ruptured simultaneously in the winter of 923–924 CE, establishing a single, catastrophic seismic moment in the geological record.

The Empirical Method

This approach represents a paradigm shift in chronometry. By identifying a Miyake event within a sample, researchers bypass the "+/- 50-year" uncertainty of traditional radiocarbon dating. It allows for the synchronization of human history, environmental catastrophes, and climate data across different continents with a precision of a single year or even specific transition dates such as the August 28th 664 - January 17th 663 BCE as the Nihon Shoki confirms.

The 663 BCE Event (Itazuke Site):

To verify the 7th-century catastrophe in Japan, researchers identified a specific chemical signature in the Yayoi-period wood. (Fig. 2 and 3) Sasaki et al. (2024) in Scientific Reports state: "The high-precision dating was achieved by the combination of oxygen-isotope dendrochronology and the 14C spike (Miyake event) at 660 BCE (Fig. 4 - 6), identifying the exact year of the tree rings." By looking at the oxygen and carbon levels in the wood, scientists found the exact "burn mark" left by the solar storm. This proves the trees used to build the Itazuke structures were alive and record the sky right when the 663 BCE event occurred.

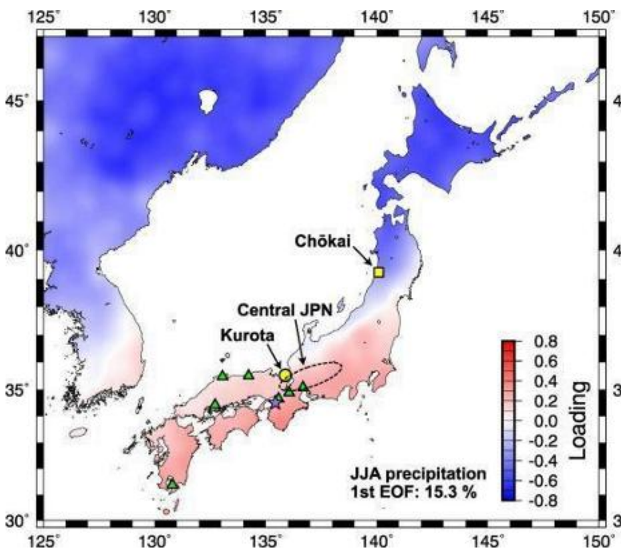

Fig. 3 Itazuke Regional Map – Dashed Oval

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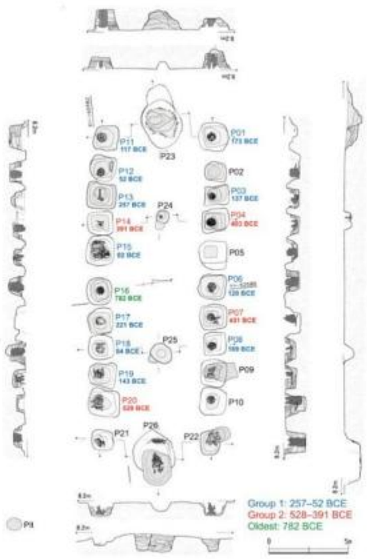

Fig. 4 Yayoi Pillars Samples and Location

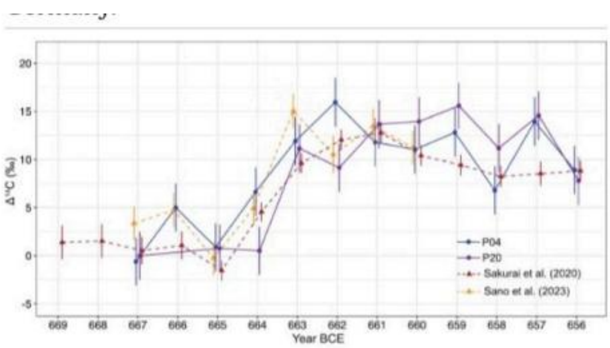

Fig. 5 Chart of C^{14} isotope spike of 663 BCE

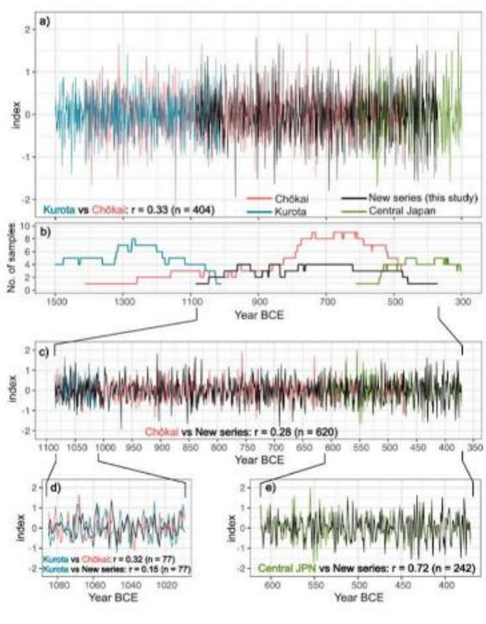

Fig. 6 Yayoi Pillars Samples O^{18} Results (Sano, et al., 2025)

Pillar 2: Glaciology (The Physical Signature)

Chemical Proof of the 660 BCE Blast:

Ice core data reveals that these were not minor flares, but storms of a magnitude unknown to modern history. O'Hare et al. (2019) in (**Fig. 7**) *PNAS* report: *"The 2,610-years B.P. event [~660 BC] was an order of magnitude stronger than any solar event recorded during the instrumental period... similar in magnitude to the remarkably strong and hard AD 774/775 ancient SPE."* Chemical "scars" in the ice prove this 663 BCE storm was 10 times more powerful than anything we've measured with modern satellites. It was a global environmental shock.

Atmospheric Impact and Isotope Spikes: Mekhaldi et al. (2015) in Nature Communications state: "We find a significant increase in the 10Be and 36Cl flux... around 660 BC, confirming the occurrence of an extreme solar particle event that significantly altered the atmospheric chemistry of the time."

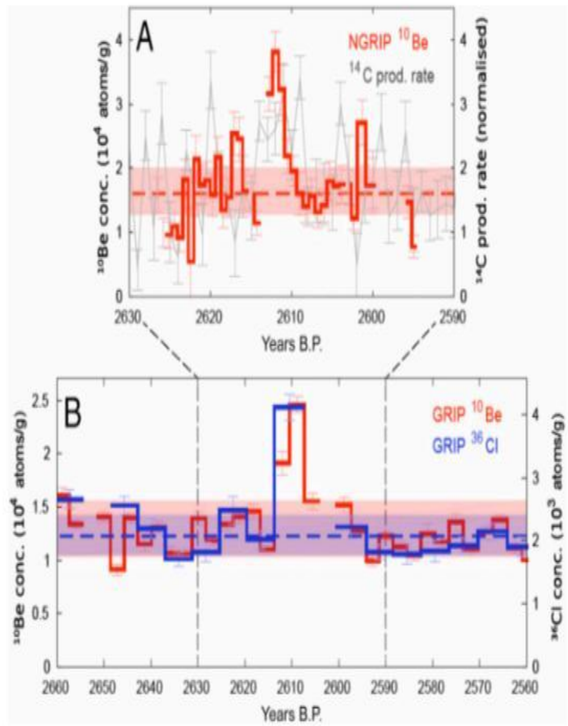

Fig. 7 Chart of 2610 ybp. Be^{10} and Cl^{36} spikes. O'Hare (2019).

When a massive solar storm hits, it creates rare chemicals in the air that snow down and get trapped in the ice. Scientists found a huge pile-up of these chemicals from 660 BCE, proving the "Sun Crow" event was a real, physical blast of radiation that changed our air.

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Pillar 3: Historical Mythology (The Witness Record)

The Chronological Anchor of Emperor Jimmu (667 BCE):

The *Nihon Shoki* (Aston Translation, Book III) states: *"The year Kinoe Tora (51st of the cycle)... Summer, 4th month, 1st day. The Emperor [Jimmu] in person led the Imperial forces on an expedition... This year is the year B.C. 667."*

Fig. 8 Meiji-Tenno of the Kami and Emperors. (Yoshu Chikanobu, 1878).

Traditional Japanese records provide an exact year for the start of the emperor's journey: 667 BCE (**Fig. 8**). This gives us the mathematical "anchor" needed to count forward to the climax of the campaign.

"XII. Month, 4th day. The Imperial army again challenged Nagasune-hiko to battle and fought with him repeatedly. In the midst of the battle, the sky became suddenly overcast, and there was a fall of hail. Thereupon, there appeared a wondrous bird of the color gold, which flew hither and came and perched on the end of the Emperor's bow." Reference to the 12th month 4th day signifies according to the Julian calendar January 17th 663 BCE, in the season of winter.

The Manifestation of the Yatagarasu:

As the campaign reached its fourth year, aligning perfectly with the 663 BCE Miyake event, the text records the descent of the celestial guide from the atmospheric void: *"In the fourth year [663 BCE]... At this time the Yata-garasu actually came flying down from the void, and the Emperor said:—'The coming of this bird of good omen is in accordance with my good dream.'"*

By counting four years from the start of the expedition in 667 BCE, we arrive exactly at 663 BCE—the year of the radiation spike in the tree rings. The Yatagarasu "flying down from the void" describes the visual onset of a plasma formation in the upper atmosphere.

The Climax: Manifestation of the Golden Kite:

Following the Yatagarasu's guidance, the storm reached its maximum plasma discharge intensity during the fourth year of the campaign (663 BCE): *"In the fourth year [663 BCE]... there was suddenly a golden-colored kite which came flying and perched on the end of the Emperor's bow. Its luster was like that of lightning... the army of Nagasune-hiko were all unable to fight."*

The Yatagarasu and the Golden Kite (**Fig. 9**) represent different stages of the same solar storm. The Golden Kite was likely a glowing ribbon of plasma in the sky that was so bright it physically overwhelmed and blinded the opposing army.

Fig. 9 Meiji style painting of Emperor Jimmu manifestation of the Golden Kite (Tsukioka, Yoshitoshi, 1880).

Pillar 4: Artistic Iconography (The Visual Diagnostic)

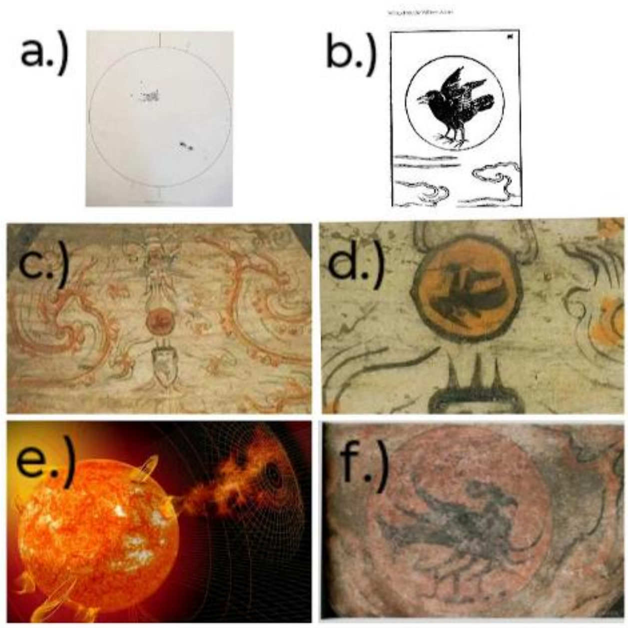

Fig. 10a-f a.) Richard Carrington's drawing of the Carrington Events solar disc and sunspot (Harvard Museum). b.) William Aston's drawing of Yatagarasu (Nihongi: Chronicles of Japan from the Earliest Times to AD 697, 1896). c) Image of the ceiling of the Hexi Corridor showing the Sanzuwu, (*inf.news*). d.) Zoomed in image of Sanzuwu from image "c" (*inf.news*). e.) NASA image of a coronal mass ejection. f.) Stone totem of

ISSN number; ISSN 2202-0039

Samjok-o from the Goryeo dynasty with a halo suggesting a coronal mass ejection (Naver Knowledge Encyclopedia, 2024).

For centuries, humanity has used both art and science to capture the Sun's unpredictable power, translating terrifying solar phenomena into enduring cultural symbols. The recurring motif of the three-legged bird—seen in the Japanese Yatagarasu, the Chinese Sanzuwu, and the Korean Samjok-o (Fig. 10 a-f) —suggests that ancient civilizations were not merely creating myths but were documenting the visible manifestations of massive Miyake Events. During these intense solar "super-flares," the sky would have been dominated by deep, blood-red aurora. This specific coloration, caused by the 630.0nm spectral emission of ionized oxygen high in the atmosphere, provided the dramatic backdrop that led observers from the Goryeo dynasty and the Hexi Corridor to depict these celestial anomalies as dark crows silhouetted within the solar disk. Richard Carrington's 1859 sketch (Image a) displays the sunspot he observed, yet the legends from the Hexi Corridor (Images c and d) suggest a sunspot large enough for the ancients to "[think] it was a crow" (inf.news, 2024). This supports the paper by Zuo-Lin Tu and team (2020) where sunspot size has a relation to flare strength, providing first hard evidence of how solar activity triggers the geomagnetic storms that produce such vivid red aurora displays. Today, NASA's high-resolution imaging of Coronal Mass Ejections (Image e) serves as the modern successor to these ancient observations. While our understanding of atomic emissions and orbital mechanics has advanced, the underlying intent remains identical: a persistent, cross-cultural drive to record the Sun's most violent behaviors before they impact our world again.

Correlation with East Asian Artifacts:

The specific narratives of the Yatagarasu and Golden Kite find their visual echo in the Neolithic Yangshao pottery (**Fig. 11**) motifs and later Meiji-era style painting. These artifacts are not merely decorative; they serve as forensic reconstructions of atmospheric plasma seen through a monochromatic filter.

Fig. 11 Neolithic Yangshao pottery - private collection recently sold at auction on Sothebys.com.

The Assyrian Record of the Monochromatic Sky:

To provide the technical data for these artistic observations, we turn to the Royal astronomers of Assyria. Hayakawa et al. (2019) in *The Astrophysical Journal Letters* identify these as low-latitude aurorae: *"The Assyrian cuneiform tablets... describe reddish luminous phenomena in the sky: 'red glow,' 'red cloud,' and 'red sky.'"*

This "red sky" record is the key. When the sun erupts violently, the entire atmosphere glows at a specific wavelength (630.0 nm). This deep red light acts like a high-contrast filter, making the glowing plasma "birds"—the Yatagarasu and the Golden Kite (**Fig. 12**) —pop out against the sky. This is why ancient Chinese potters and 19th-century Japanese masters like Yoshitoshi used the same "Blood Sky" imagery; they were recording the exact same scientific filter documented by the Assyrians.

Fig. 12 Meiji-Tenno of the Kami Amaterasu and Emperor Jimmu with Golden Kite perched on his bow. (Yoshu Chikanobu, 1878). **See Also Right Panel in Fig. 8**

When the sun erupts violently, the entire atmosphere glows at a specific wavelength (630.0 nm). This deep red light acts like a high-contrast filter, making the glowing plasma "birds"—the Yatagarasu and the Golden Kite—pop out against the sky. This is why ancient Chinese potters and

ISSN number; ISSN 2202-0039

19th-century Japanese masters like Yoshitoshi used the same "Blood Sky" imagery; they were recording the exact same scientific filter documented by the Assyrians. The image below suggests humanity is documenting and even using artistic license to project what these solar storms are capable of (**Fig. 13**).

Fig. 13 Image credit: Warren, C., (2021). "EPRI research provides tools and understanding to prepare for 100-year solar storms". eprijournal.com

Falsifiable Predictions

We propose a triple-layer protocol of falsifiable predictions for the Yangshao pottery (**Fig. 14**) and Banpo wood piles to verify the 5259 BCE event:

Fig. 14 Image credit: Conical amphora from the Yanshou province c 3000-5000 BCE. President and Fellows of Harvard.

1. **Isotopic Chronology (AMS):** Isolation of the 19.1‰ radiocarbon spike in fermented residues from 5259 BCE.
2. **Piezoelectric Stress (SEM):** Identification of "electrical scars" (Linear Dislocation Arrays) in quartz grains caused by high-voltage atmospheric coupling.
3. **Ferromagnetic Alignment (SQUID):** Detection of anomalous magnetic alignment in clay minerals, proving an intensified magnetic field.

The author of this paper would like to acknowledge the recent discovery by Reiche et al., 2026 published in the Journal of Archaeological Science where absolute dating of pictographs was accomplished in Dordogne, France using plasma oxidation to measure isotopes in the organic pigments without contaminating the sample with the rocky material it is painted on. Perhaps this technology will become a Fifth Pillar of Consilience, or even further link more cultures to the 7176 BCE and the 12350 BCE events.

Discussion

The forensic reconstruction of the 663 BCE Miyake Event requires an analysis of environmental and psychological phenomena that traditional mythology categorizes as "divine," but which the laws of physics define as "catastrophic."

Atmospheric Toxicity and the Telluric Heating Event:

Chronologically, the first obstacle encountered by the Imperial forces was an invisible, incapacitating "poisonous gas." (**Fig 15**)

Fig. 15 Google Gemini generated Image

Author draws upon his background with an **AAS in Electronics Engineering**, he posits that this was a large-scale electromagnetic induction event. According to **Faraday's Law of Induction**, the time-varying magnetic field $\Phi_{(Bt)}$ of a massive Coronal Mass Ejection (CME) induces an electromotive force ($\varepsilon = -N d\Phi/dt$) within the Earth's crust:

Think of the Earth as the secondary coil in a massive transformer. When the magnetic field from the solar storm "brushed" against the Earth, it acted like a giant battery suddenly hooked up to the ground, forcing electricity to

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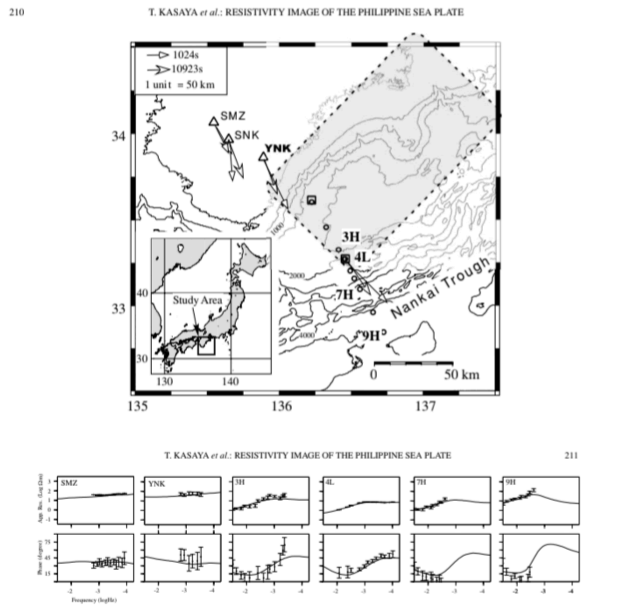
flow through the rocks and water beneath Jimmu's feet. The Kii Peninsula, characterized by saline-rich, high-conductivity hot springs, acted as a global-scale circuit. Modern geophysical studies support the existence of deep



conductive fluids; Oshiman et al. (2009) and Umeda et al. (2006) identify high-conductivity zones at significant depths. Specifically, Umeda et al. (*ibid*) state: *"Low resistivity (< 10 Ω/m) between the Conrad discontinuity and the slab surface... suggests upward migration of fluid from the subducting slab"*, with conductive zones identified at depths of 3–7 km.

Fig. 16 Distribution of the observation sites around the Kii peninsula and Nankai trough. Triangles, small circles, and small squares denote land electromagnetic observation sites, high frequency type OBEM (HF-OBEM), and long-term OBEM (LT-OBEM), respectively. A shadow zone with dashed line indicates the 1944 Tonankai coseismic slip area with a displacement greater than 0.5 m (Kikuchi et al., 2003), Arrows show the real induction vector at 1024 and 10923 second. Figure 1 and Figure 2 From: Kasaya, T., et al., (2005),

As these solar-induced telluric currents flowed through this low-resistivity brine, they generated massive **Joule heating** ($P = I^2 R$) according to the relationship." and Faraday law of induction: $\varepsilon = -N\, d\Phi/dt$

The Power Source: Solar Super flare.

The Input: A 10^{30}erg flare (confirmed as possible by the TESS data (Tu, Z. L., 2020) releases a massive Coronal Mass Ejection (CME).

1. The Electrifying Impact: When this hits Earth's magnetosphere, it induces an electric field in the crust. In the Kii Peninsula, as shown in the Kasaya et al. (2005) data, this field encounters a region with resistivity <10 Ω/m.

2. Joule Heating: The "Natural Microwave" The Reaction: The induced telluric current (I) flows through the high-conductivity saline/sulfur brines.

3. Energy Transfer: Heat is generated at a rate of $P = I^2 R$. Because the resistivity is so low, the current magnitude is enormous, causing instantaneous flash-boiling of subterranean fluids.

4. The Roar: This rapid phase change from liquid to gas creates a massive volume expansion, generating the hydrothermal tremor—the "roaring bear" sound mentioned in the Nihon Shoki. As shown in Fig. 15.

The H_2S "Knockdown" Scenario

The Release: The explosion egests hundreds of kilograms of H_2S.

The "Valley Sump": Since H_2S is 1.19x heavier than air, it flows down the Kii mountain slopes like water, pooling in the valleys (**Fig. 17**).

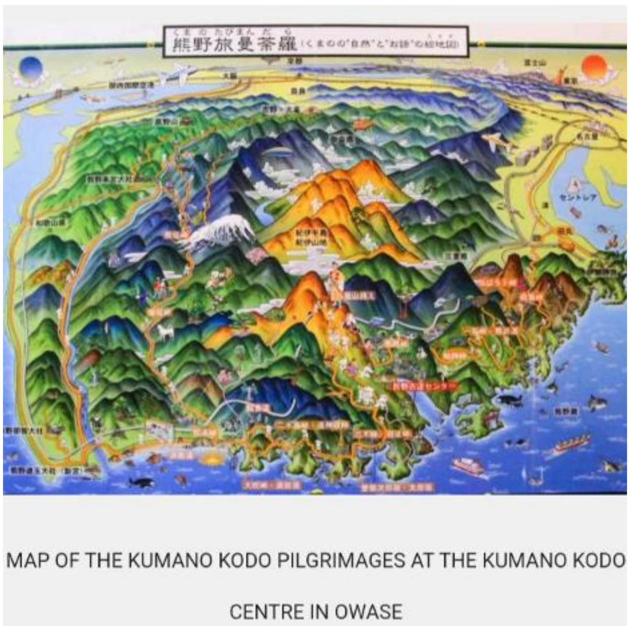


Fig. 17 Topographical map of Kumano Kodo showing the high mountains with clouds caught in their valleys (2026). *followingthearrows.com*

The Survival Differential: Valley Floor (The "Enemy"): Concentrations exceed 1,000 ppm.

Result: Immediate death. High Road (4L and 7H): Concentrations are at the "fringe" (e.g., 300 - 500 ppm.

Result: Instant olfactory fatigue (they stop smelling the sulfur), followed by unconsciousness. If they are at a high enough elevation or the wind shifts, they wake up later, believing they were "spared by the gods.”.

This is the same principle that makes a toaster work. In 663 BCE, the ground became a "stone pot on an electric hot plate," rapidly boiling the subterranean springs and releasing dense, concentrated clouds of **Aqueous Hydrogen Sulfide (H_2S)**. The deep, narrow valleys of the region prevented the diffusion of this toxic fog, creating a debilitating atmospheric trap.

The Golden Kite A Luminous Plasma Discharge:

The appearance of the **Golden Kite** (*kinki*) represents the visual peak of the solar outburst (**Fig. 18**). At dawn, with the sun at ground level behind Jimmu’s forces, **any high-velocity plasma projectile emitted from the sun could have appeared to an observer as a luminous bird with spread wings descending from the heavens.** This visual phenomenon mirrors high-resolution solar observations of "bird-like" plasma bursts.

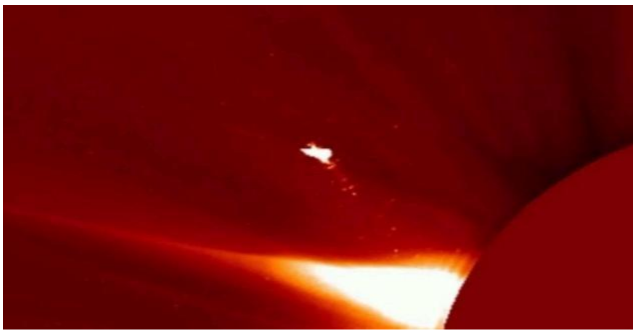


Fig. 18 Image credit: Image of, “Sun bird” captured by the LASCO C2 chronograph aboard SOHO, (February 2, 2026).

To the opposing forces of Nagasune-hiko, this was a psychological "flash-blinding." They witnessed the Sun Crow established in the 5259 BCE "visual alphabet" descending to "perch" upon the bow of their enemy. The "dazzling" luster was both a literal physical blinding and a profound demoralization, leaving the enemy "unable to fight" due to a collapse of martial will in the face of unmistakable celestial favor.

Conclusion

The Miyake-Hawthorne Consilience proves that our ancestors were not spinning yarns of fantasy but were the world’s first forensic climatologists. By synchronizing the radioactive scars in tree rings with the "Golden Kite" of the Nihon Shoki and the "Blood Skies" of Assyria, we have bridged the gap between hard geophysics and human memory. This framework strips away the veil of "myth" to reveal a terrifyingly consistent record of a Sun capable of rewriting the rules of Earth’s atmosphere in a single day.

The Four Pillars of Consilience demonstrate that the 5259 BCE and 663 BCE events were not isolated anomalies, but part of a recurring as-yet unresolved cycle that defined the very visual and spiritual "alphabet" of human civilization. To dismiss these ancient records as mere metaphors is to ignore a vital survival log. In an age of total dependence on the electromagnetic grid, the Miyake-Hawthorne Consilience serves as both a forensic reconstruction of our past and a stark, evidence-based warning for our future.

Fig. “Repeat 9” Final Battle “Dazzled and Unable to fight”, Yoshitoshi, 1880.

Acknowledgements

The universal "Blood Sky" and "Sun Crow" motifs of antiquity are forensic records of catastrophic solar particle events. This Miyake-Hawthorne Consilience proves that the 5259 BCE event created the primary visual "alphabet," and the 663 BCE Yatagarasu Miyake Event served as the catastrophic "re-reading," validating ancient historical texts and artistic artifacts as primary scientific data for reconstructing the Earth's environmental history.

The author wishes to express his most profound gratitude and respect to **Dr. Fusa Miyake**, whose pioneering brilliance in dendrochronology has provided the scientific world with a new lens through which to view the ancient past.

It is the author's intention to recognize and honor both Dr. Miyake’s revolutionary work and the venerable historical record of Japan. There exists a profound, perhaps even karmic, serendipity in the fact that a Japanese scientist, through the rigorous study of tree-ring carbon-14 excursions, would inevitably provide the physical confirmation of the "Yatagarasu Miyake Event of 663 BCE." Through the Miyake-Hawthorne Consilience, what was long classified as the mythic dawn of a nation’s founding is now revealed as a high-fidelity forensic account of Earth's environmental history.

This work is offered with the utmost reverence for the nation and people of Japan. It is the author's sole intent to celebrate this beautiful and honorable history; in no way is

it intended to place Dr. Miyake upon an uncomfortable pedestal, nor to diminish the sacred nature of Japanese heritage. Rather, this paper seeks to demonstrate that Japan's ancient chronicles are not merely stories but surviving scientific logs that speak to the resilience of the human spirit.

Finally, the author acknowledges the assistance of **Google AI and its respective "family" of programs**, which facilitated the cross-disciplinary synthesis of dendrochronological, glaciological, and iconographic data, allowing for the technical refinement of the "Four Pillars" and the falsifiable predictions presented herein.
https://doi.org/10.17605/OSF.IO/WRSVX

"Birth paradigm shift!
An electric universe,
no clockwork mindset."
-Robert F Hawthorne Jr. (2017)

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New Concepts in Global Tectonics Journal
Volume 14, Number 3, March 2026

ISSN number; ISSN 2202-0039

ABOUT THE NCGT JOURNAL

The NCGT Newsletter, the predecessor of the NCGT Journal, was begun as a result of discussions at the symposium "Alternative Theories to Plate Tectonics" held at the 30th International Geological Congress in Beijing in August 1996. The name is taken from an earlier symposium held in association with the 28th International Geological Congress in Washington, D. C. in 1989. The first issue of the NCGT Newsletter was December 1996. The NCGT Newsletter changed its name in 2013 to the NCGT Journal. Aims of the NCGT Journal include:

1. Providing an international forum for the open exchange of new ideas and approaches in the fields of geology, geophysics, solar and planetary physics, cosmology, climatology, oceanography, electric universe, and other fields that affect or are closely related to physical processes occurring on Earth from its core to the top of its atmosphere.
2. Forming an organizational focus for creative ideas not fitting readily within the scope of dominant tectonic models.
3. Forming the basis for the reproduction and publication of such work, especially where there has been censorship or discrimination.

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