A New Interpretation of Ptolemy's *Germania Magna*

Cartometric Evidence and a Geodynamic Framework for Post-Antique Landscape Transformation in Central Europe

Version 5 — May 2026
(revising and superseding Version 4 of May 2026)

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How to cite this preprint:

Mildner, S. (2026). *A New Interpretation of Ptolemy's Germania Magna: Cartometric, Geodynamic, and Historical Evidence for a Long-Term Transgression and Post-Antique Regression of the Oceanus Germanicus in Central Europe* (Version 5). EarthArXiv (Preprint).
`https://doi.org/10.31223/X5313T`

Related, extended technical resource:

Mildner, S. (2026). *Geodynamic Reinterpretation Model for Ptolemy's Germania Magna: General Model Description, Cartometric Foundations, Extended Evidence Analysis, and Impact Hypothesis* (v4). EarthArXiv.
`https://doi.org/10.31223/X5KB51`

Keywords: Ptolemy, *Germania Magna*, transgression, regression, *Oceanus Germanicus*, *Vistula Fluvius*, *Asciburgius Mons*, coastline shift, Caledonian Deformation Front, Trans-European Suture Zone, Avalonia, Baltica, Scandia, Blinkerwall, Tollense Valley, King Berig, Jordanes, 536 AD crisis, Late Antique Little Ice Age, Event-Dark-Earth, settlement hiatus, Migration Period, Gregory of Tours, Frankish Annals, *Annales Bertiniani*, tectonic settling, *Donnus Nicolaus Germanus*, comets, Barbarossa.

Disclaimer and scope

This manuscript presents an interdisciplinary working hypothesis integrating cartometry, geodynamics, palaeoenvironmental reconstruction, archaeology, and historical chronology. It formulates concrete, falsifiable predictions and is intended to stimulate further empirical testing. It does not claim to constitute a definitive reconstruction, and has not been evaluated by peer review.

Contents

Abstract

This paper revises and extends the author's earlier interpretation of Claudius Ptolemy's *Germania Magna* (c. 150 AD) by combining a cartometric analysis of the medieval map redaction of Donnus Nicolaus Germanus with evidence drawn from geodynamics, palaeohydrology, palynology, archaeology, and historical chronology. Its central thesis is that the apparent discrepancies between Ptolemy's coordinate system and the modern Central European landscape are not primarily the result of ancient measurement error, as the prevailing geodetic-rectification school has assumed, but the cumulative product of two superimposed factors: a substantial, geologically recent transformation of the landscape itself, and the inevitable cartographic distortion that arose when medieval and early-modern editors re-projected Ptolemy's coordinates onto an already changed terrain without recognising the underlying shift.

The most consequential change concerned the coastline of the *Oceanus Germanicus*. During antiquity, this coastline ran approximately 120 km south of its present position, just north of present-day Berlin, at the latitude of Eberswalde. North of this line stretched not open sea in the modern sense, but a wide amphibious zone of marshes, reed flats, shallow lagoons and reticulated waterways — a landscape that on approach from the sea offered no clear shoreline at all. Within this framework, the *Vistula Fluvius* of Ptolemy corresponds not to the modern Polish Vistula but to the Lusatian river system of the Schwarze Elster, Spree and Oder; the *Asciburgius Mons* corresponds not to the Sudetes but to the Fläming and its south-eastern foothills; and the southern boundary river that Ptolemy calls *Danubius* may, on a revised reading, correspond to the modern Main rather than to today's Danube, with the *Abnoba Mons* of his text identified with the Taunus rather than the Black Forest.

The hypothesis advanced here is that the relevant landscape transformation occurred in geologically recent time — most plausibly during a window centred on the mid-sixth century AD — and was driven by a late-stage reactivation of the Caledonian Deformation Front (CDF) and adjacent structures of the Trans-European Suture Zone under the compressional regime of the closing Alpine orogeny, with the possibility of an impact or airburst trigger of cometary origin that may have catalysed the deformation. The proposed framework offers a unified explanation for the archaeological settlement hiatus of the fifth to seventh centuries, the abrupt collapse of arboreal pollen curves in the same window, the Late Antique Little Ice Age now widely recognised in tree-ring records (Büntgen et al., 2016), the political collapse of the Thuringian kingdom in 531 AD, and the subsequent Slavic re-colonisation of an emptied and ecologically reset landscape.

1. Introduction: The Central Problem

The geography of *Germania Magna*, transmitted in Book II, Chapter 11 of Ptolemy's *Geographike Hyphegesis*, has occupied scholarship for centuries (Stückelberger & Grasshoff, 2006). The dominant modern paradigm — the statistical-geodetic rectification of Kleineberg et al. (2010) and Karlsen et al. (2011) — treats deviations between Ptolemaic coordinates and the modern landscape as compounded instrumental and transmission errors, removable by spatial adjustment. The approach is methodologically rigorous and has produced an impressive index of identifications. Yet it rests on a premise that is rarely stated explicitly: that the physical landscape itself has remained essentially constant since antiquity.

The present work proceeds from a different premise. It asks what would follow if one took the Ptolemaic record at face value as a substantially accurate description of an ancient landscape, and treated the apparent discrepancies with modern topography as evidence of *real change*.

The argument has a specific logical architecture that distinguishes this version from all previous iterations. It is not simply that the landscape changed; it is that the landscape changed in a *directional, sequential* way that can be reconstructed with precision. First came a very long transgression — a gradual rise of relative sea level in the southern Baltic and North Sea that unfolded over millennia, from the Stone Age through to Roman times, and whose consequences for human settlement and culture are directly documentable in the archaeological record. Then came an abrupt regression — a geodynamically driven withdrawal of the sea that shifted the coastline of the *Oceanus Germanicus* approximately 120 km northward in late antiquity, transforming the landscape so dramatically that the medieval scholars who subsequently re-encountered Ptolemy's coordinates could not recognise them as describing their own world.

Crucially, the regression postdated Ptolemy. His data accurately captured the transgressive maximum — the landscape as it was in the 2nd century AD. The catastrophic events of the 6th century that ended the transgression happened after Ptolemy published, creating an irrecoverable break in topographic continuity. When medieval scholars rediscovered the *Geographike Hyphegesis* a thousand years later, they faced the task of projecting a coordinate system anchored on a southerly ancient coastline onto a present landscape whose coastline had retreated far to the north. All subsequent cartographic distortion follows necessarily from this mismatch.

The argument unfolds as follows. Section 2 establishes the cartometric foundation. Section 3 reconstructs the long transgression from the Stone Age to late antiquity. Section 4 examines the catastrophic events of 525–536 AD that terminated the transgression. Section 5 documents the subsequent regression and its post-antique tectonic consequences. Section 6 develops the geodynamic framework. Section 7 develops the *Event-Dark-Earth* hypothesis. Section 8 reconsiders *Scandia* in this integrated light. Sections 9–10 synthesise the evidence and articulate falsification pathways.

2. Cartographic Foundation

The principal cartographic source is the *Quarta Europae Tabula* of Donnus Nicolaus Germanus, preserved in the late-fifteenth century printed editions of Ptolemy's *Geographia.* This map is a medieval reconstruction that preserves Ptolemy's coordinate data with surprising topological fidelity; the apparent errors it contains are, as the present analysis shows, systematic in a way that immediately points to their underlying cause.

2.1 Reference Lines and the Global Scaling Factor

The cartometric reconstruction anchors on four physically invariant reference structures: the Rhine (*Rhenus Fluvius*), whose middle and lower course has not migrated materially since antiquity; the Elbe (*Albis Fluvius*), similarly stable; the Fläming–Lusatia tectonic hinge zone (identified with the *Asciburgius Mons*; §2.3); and the eastern margin at the Oderbruch–Ziltendorfer Niederung zone.

The distance between the Rhine and Elbe mouths (approximately 115 km) over a Ptolemaic longitude difference of $\Delta\lambda_P = 4°$ yields:

$$k_1 = \frac{115 \text{ km}}{4°} \approx 28.75 \text{ km per Ptolemaic degree} \quad (1)$$

A second, longer baseline from the Rhine mouth to the reconstructed *Vistula Fluvius* mouth at Oderberg ($\lambda_P = 45°00'$), spanning approximately 490 km over $\Delta\lambda_P = 18°$, yields:

$$k_2 = \frac{490 \text{ km}}{18°} \approx 27.22 \text{ km per Ptolemaic degree} \quad (2)$$

The weighted mean produces a robust global scaling factor of approximately $k \approx 28$ km per Ptolemaic degree of longitude. Applying this factor with the Rhine and Elbe as calibration points, the northern coastline of the *Oceanus Germanicus* falls approximately **120 km south of its present position**, at $\approx 52°50'$ N — the latitudinal vicinity of Eberswalde.

This result is the cartometric anchor of the entire subsequent argument. It is not an assumption; it is the *result* of applying the empirically derived scaling factor to the Ptolemaic data and asking where the northern coastline must have been for the map to be internally consistent.

2.2 The *Vistula Fluvius* as the Lusatian River System

The 120-km southward coastal displacement has an immediate and decisive consequence for the eastern boundary river. If the *Vistula Fluvius* mouth lies at the ancient coastal latitude, it must be located approximately 120 km further south than any currently accepted identification assumes — in the region of the present-day Oderbruch or Ziltendorfer Niederung.

Following the Ptolemaic coordinate grid from this mouth, and observing the specific topology that Ptolemy imposes — (a) two major source branches, (b) more than 50% of the total course lying *south* of the *Asciburgius Mons*, (c) the branches converging *east* of that range — the modern Polish Vistula cannot possibly satisfy these requirements. It rises on the Silesian Beskids, far too far north and east of the required positions, and has no dual-source structure of the type Ptolemy describes.

The **Lusatian river system** — the complex of the *Schwarze Elster*, the *Spree*, and the upper *Oder* — satisfies all three constraints simultaneously:

- One source area lies in the **Königsbrücker Heide** (ancient *Krakow* area), corresponding to a western branch of the Spree system;
- A second source area lies further east near **Königswartha**, corresponding to an eastern branch;
- These branches converge east of the Fläming (*Asciburgius Mons*) in the Lusatian lowlands;
- The system flows to a mouth in the Oderberg area at precisely the required coastal latitude.

An important etymological observation reinforces this. The Greek *Oustoúla* (*Οὐστοὐλα*) most plausibly derives from Latin *ustulō* — to scorch, to char, to smoulder — related to the English *ustulate* (blackened by fire; to roast ores). The Lusatian region is archaeologically one of the most intensively documented centres of bog-iron metallurgy in the pre-Roman and Roman Iron Ages (over 200 smelting furnaces at Elsterwerda). The modern German name *Schwarze Elster* (Black Elster) may itself preserve a memory of this ancient identifier.

An important clarification: this identification does *not* postulate that the Vistula physically migrated eastward. The river courses did not move. What shifted was the cartographic projection: under forced northward stretching to accommodate the unknown coastal shift, the Lusatian system was projected far enough east to appear to coincide with the modern Polish Vistula.

Internal Proportions: A Quantitative Cross-Check

According to Ptolemy's coordinates, the *Vistula Fluvius* mouth sits roughly 1.25× further east of the Harz mountains than the Harz is from the Rhine. Using the Rhine–Harz distance as a reference (approximately 260 km), this ratio predicts a Harz–to–Vistula-mouth distance of approximately 325 km. The actual distance from the Harz to the mouth of the Oder system (Oderberg: Mildner's model) is approximately 300 km — a remarkably close match. The distance to the mouth of the modern Polish Vistula (the Lelgemann model) is approximately 620 km — nearly double the predicted value, and an unjustifiable stretching of the entire coordinate system.

2.3 The *Asciburgius Mons* as the Fläming

The identification of the *Asciburgius Mons* with the **Fläming** and its south-eastern foothills (Calauer Schweiz / Niederlausitzer Landrücken) follows necessarily from the Vistula reidentification. The distinctive southward curve of the range depicted on the Germanus map corresponds geometrically and structurally to the tectonic hinge zone of the Fläming–Lusatia complex, with the rigid Lusatian Granodiorite Block acting as a kinematic pivot.

Specific settlement identifications within and around this structure:

Ptolemaic name	Modern identification	Significance
Limios Alsos / Limis Lucus	Baruth/Mark (NE Fläming)	Northern margin anchor
Budorigum	Doberlug-Kirchhain	Anthracite / stress metamorphism
Calisia	Calau (Niederlausitz)	East of Senftenberg pivot
Stragona	Herzberg/Elster	2024 earthquake epicentre
Lugidunum	Falkenberg/Elster	Elster river settlement

2.4 A Revised Southern Boundary: *Danubius Fluvius* as the Modern Main, *Abnoba Mons* as the Taunus

The conventional identification of the *Danubius Fluvius* with the modern Danube rests on Tacitus's statement (*Germania* 1) that the Danube rises on the *Abnoba Mons* and on the standard identification of that range with the Black Forest (Tacitus, c. 98 AD). When the $k \approx 28$ km/°scaling is applied to Ptolemy's *Abnoba Mons* coordinates, the result places the range considerably further north than the Black Forest — in the area of the present-day **Taunus**, immediately south of the lower Rhine valley. Tacitus's description of the *Danubius* rising from a "gently and softly elevated ridge" is consistent with the Taunus morphology; and Ptolemy's placement of Mogontiacum (Mainz) at the river's headwaters is reconciled naturally if the river is the **Main** rather than the Danube.

Furthermore, the deeply meandering course of the modern Main between Bamberg and Mainz — strikingly anomalous among comparable Central European rivers — may represent a late-tectonic feature: the consequence of NNW–SSE-directed crustal shortening from the proposed block rotation of the Thuringian Forest (Section 6.2). This revised reading implies that *Germania Magna* was more compact in north–south extent than the conventional reading allows, bounded to the south by the present-day Main valley. The identification is offered as a working hypothesis explicitly open to falsification.

2.5 The Mechanism of Medieval Cartographic Distortion

The geometry of the distortion is straightforward. When medieval scholars placed Ptolemy's *Oceanus Germanicus* coastline as their northern reference and identified it with the sea they actually observed along present-day Schleswig-Holstein and Pomerania, the entire Ptolemaic grid was automatically stretched northward by $\approx$ 120 km. This northward stretch is not merely a vertical shift; it produces a *proportional east–west expansion* to preserve the map's internal aspect ratios. The further east a feature lies from the western Rhine anchor, the larger its eastward displacement under the forced stretching. This is precisely the signal observed in the residual analysis: a coherent, directional, westward residual of $\Delta\lambda = -93.1$ km for the Elster Cluster ($t = -13.7$, $p < 0.001$, $df = 3$), increasing systematically with distance from the western reference, not scattered randomly as measurement noise would be.

2.6 Against the Rubber-Sheeting Critique

The present reconstruction is *not* an unconstrained image distortion. It is a rigidly constrained affine transformation, subject to four independent conditions that must be satisfied simultaneously:

1. **Geometric scaling rigidity**: $k \approx 28$ km/°derived from the empirically verifiable Rhine–Elbe baseline;
2. **Hydrographic topological constraint**: two major source branches south of and converging east of the *Asciburgius Mons* — uniquely satisfiable by the Lusatian system;
3. **Cartographic curvature**: the Germanus-map curve of the *Asciburgius Mons* must correspond to a geologically verifiable tectonic hinge zone;
4. **Geochemical anchor**: the cartometric identification *Budorigum* = Doberlug-Kirchhain is cross-validated by the independently anomalous near-surface anthracite mineralisation at that location (stress metamorphism).

No unconstrained digital distortion algorithm can satisfy all four constraints jointly; algorithmic least-squares minimisation inevitably smooths the tectonic signal back onto the Polish Vistula, leaving the topological impossibility unresolved.

Section Summary: Cartographic Foundation

Applying a scaling factor of ≈ 28 km per Ptolemaic degree of longitude to the Rhine–Elbe baseline, the northern coastline of the *Oceanus Germanicus* falls ≈ 120 km south of its present position at ≈ 52°50′ N. The *Vistula Fluvius* is identified with the Lusatian Schwarze Elster–Spree–Oder system on converging topological, etymological, and demographic grounds. The *Asciburgius Mons* corresponds to the Fläming. The *Danubius Fluvius* tentatively corresponds to the modern Main, with *Abnoba Mons* as the Taunus. The dominant systematic discrepancy arises not from primary measurement error in Ptolemy but from medieval re-projection onto a transformed landscape, compounded by editorial scaling errors at the boundary between adjacent chapters of the *Geographike Hyphegesis*.

3. The Long Transgression: Stone Age to Late Antiquity

A central insight of this paper is that the Ptolemaic coastline position — 120 km further south than today — was not the result of any sudden event, but the endpoint of a very long, gradual transgressive process unfolding over millennia. To understand why the sea stood where Ptolemy recorded it, we must trace this process from its beginning.

3.1 The Stone Age Baseline: The *Blinkerwall*

The most vivid material evidence for the former extent of dry land in the southern Baltic is the ***Blinkerwall*** (Geersen et al., 2024): a 971-metre-long submerged Stone Age hunting structure of 1,673 stones, now lying at **21 metres water depth** in the Bay of Mecklenburg. The adjacent palaeolake sediments have been radiocarbon-dated to 9,143 ± 36 BP, establishing a *terminus post quem* for the terrestrial landscape in which the structure was built. Final submersion occurred during the Littorina transgression, ≈ 8,500–8,000 years ago.

This discovery establishes the low-sea-level Stone Age baseline with complete empirical certainty. The Bay of Mecklenburg — now open marine water — was, less than 10,000 years ago, a terrestrial or freshwater environment in which human beings built and used a kilometre-long hunting drive. The long-term Holocene transgression that subsequently submerged the Blinkerwall is the same process whose continuations, over the following millennia, progressively reduced the island of *Scandia* and ultimately produced the coastline that Ptolemy recorded.

3.2 The Littorina Transgression and Progressive Inundation

The dominant mechanism of RSL rise in the southern Baltic during the Holocene was the interaction of global eustatic rise from melting continental ice with the differential glacio-isostatic rebound of Scandinavia relative to the forebulge regions of northern Germany and Denmark. The southern Baltic coast lies in the collapsing peripheral forebulge of the Scandinavian ice sheet; as the forebulge gradually subsides, the land sinks and the sea advances.

Lampe et al. (2011) and Bungenstock et al. (2021) document the complexity of Holocene RSL history along the German Baltic and North Sea coasts, confirming substantial late-Holocene variability and establishing that the assumption of long-term coastal stability — implicit in the conventional cartographic-rectification paradigm — is unwarranted. Arfai et al. (2018) document anomalous Quaternary subsidence rates exceeding Cenozoic averages by an order of magnitude in the north-western German North Sea, confirming recent geological dynamism in precisely this zone.

The progressive Holocene inundation was not continuous. It proceeded in episodes, with periods of relatively rapid transgression interspersed with stability or brief regression. The classical traditions of antiquity preserve indirect evidence of at least one dramatic episode (Section 3.6). Through all variability, the trend was consistently toward higher relative sea level and reduced exposed land — until the reversal event of the 6th century AD that is the central subject of Sections 4 and 5.

3.3 *Scandia* in the Bronze Age: Land Loss and Demographic Pressure

The island of *Scandia* — which Section 8 identifies not as the Scandinavian Peninsula but as a topographically bounded landmass in the present-day Mecklenburg-Vorpommern / Western Pomeranian shelf zone — was, at the onset of the Bronze Age, substantially larger than in Ptolemy's time. The progressive Holocene transgression had already inundated portions of the southern Baltic shelf, but considerable areas now submerged were still above water, providing habitable territory around what would become an increasingly constrained island core.

As sea level continued to rise through the Bronze Age and into the Iron Age, this island progressively shrank. The demographic consequences were straightforward: a fixed or growing population inhabiting a diminishing land area would inevitably experience increasing resource stress, social tension, and pressure to emigrate. Ptolemy's *Scandia* recorded precisely this geographically constrained situation at its late-antique maximum-transgression configuration.

3.4 The Tollense Valley Conflict (≈300–1250 BC)

The Bronze Age finds from the **Tollense Valley** in Mecklenburg-Vorpommern (Jantzen et al., 2011) provide the most dramatic archaeological evidence for the social pressures operating in the southern Baltic hinterland during the Bronze Age. The skeletal remains of several thousand warriors, representing a highly organised, militarily equipped mobile force engaged in large-scale battle, are dated to ≈ 1300–1250 BC.

This chronological window overlaps closely with the timeframe suggested by Jordanes' narrative for the Gothic migration under King Berig, which he places approximately 2,000 years before his own writing in the mid-6th century AD (implying ≈ 13th–15th centuries BC). The two records — organised mass conflict in the immediate southern-

Baltic hinterland, and an oral memory of forced emigration from a small nearby island — are not casually linkable with precision; but their chronological and geographical proximity, combined with the demographic mechanism of progressive land loss, warrants serious consideration of an integrated scenario in which both reflect a broader Bronze Age population-pressure dynamic rooted in the same shrinking southern-Baltic island complex.

The Tollense evidence thus functions as the material archaeological complement to Jordanes' narrative: where Jordanes preserves cultural memory of pressure and migration, the Tollense finds preserve the physical evidence of organised mass violence in the same region during the same general horizon.

3.5 King Berig's Migration and Jordanes' *Getica*

Jordanes, writing his *Getica* c. 551 AD, describes the island of *Skandza* as the *vagina nationum* (womb of peoples) and *officina gentium* (workshop of peoples), from which the Goths departed under King Berig because the island could no longer feed its growing population. The departure was by sea, in three ships, to a facing mainland.

This demographic argument is entirely implausible if *Scandia* is the Scandinavian Peninsula: no Bronze or Iron Age population could have saturated the agricultural capacity of modern Norway and Sweden. The argument becomes compellingly plausible if *Scandia* is understood as the limited island massif proposed here: a territory whose progressive reduction by marine transgression over centuries would have generated exactly the kind of Malthusian pressure Jordanes describes.

Ptolemy places *Scandia* specifically "at the mouth of the Vistula River." In the reidentification proposed here — the *Vistula Fluvius* mouth at Oderberg in the Oder estuary zone, approximately 52°50′ N — the island lying at or opposite this mouth falls in the area of the present-day Usedom/Wolin archipelago: precisely the zone where a substantial southern Baltic island massif would have been prominent in Ptolemy's time.

The short sea crossing implied by Jordanes (three ships, to a facing coast) is geographically coherent for a crossing from the southern-Baltic island complex to the Pomeranian mainland. It is geographically incoherent if *Scandia* is Norway or Sweden.

3.6 The Cimbrian Flood and Late Pre-Roman Iron Age Transgressions

The classical sources preserve a tradition of catastrophic marine flooding on the southern North Sea coast that constitutes independent evidence for episodic transgression in the pre-Roman Iron Age. Poseidonios, as transmitted by Strabo (Strabo, c. 7 BC, *Geographika* VII.2.1–3), attributed the migration of the Cimbri and Teutoni (≈105 BC) to a violent inundation of their coastal homeland. Poseidonios hypothesised a sudden marine transgression caused by a violent uplift of the sea floor — physically consistent with what would today be called a tectonic tsunami or earthquake-driven seiche. Ammianus Marcellinus (Ammianus Marcellinus, c. 390 AD, XV.10.7) preserves this tradition as an established element of the classical ethnographic record into late antiquity.

Within the framework developed here, this tradition is most naturally read not as an isolated meteorological event but as one episode in the long-term, episodic transgression sequence that the *Blinkerwall* record independently documents. The Cimbrian flood tradition and the Blinkerwall converge on the same conclusion: the southern North Sea and southern Baltic coastlines were subject throughout the late Holocene to substantial transgressive events whose cumulative effect produced the ancient coastline position recorded by Ptolemy.

3.7 The Situation at Ptolemy's Time (≈50 AD)

By the time Claudius Ptolemy compiled his *Geographike Hyphegesis* around 150 AD, the long transgression had reached what appears to have been its local Holocene maximum. The coastline of the *Oceanus Germanicus* lay approximately 120 km south of its modern position, at $\approx 52°50'$ N. Several reinforcing factors contributed to this high RSL position:

- The Roman Climate Optimum — a multi-century warm interval spanning broadly the 1st century BC to the 3rd century AD — implied reduced cryospheric water storage and marginally higher eustatic sea levels;
- Ongoing glacio-isostatic subsidence of the southern Baltic forebulge was continuously adding to the RSL;
- Episodic tectonic contributions may have maintained elevated water levels in the enclosed southern Baltic basin.

Denmark — or the Jutland Peninsula — had not yet consolidated into a firm continental land connection. The map depicts the Cimbrian Peninsula as distinctly insular or loosely attached, consistent with a complex of connected and disconnected islands and shallow shelf waters rather than a robustly continuous peninsula.

3.8 The Amphibious Zone: Character, Ecology, and Strategic Significance

The ancient boundary between *Germania Magna* and the *Oceanus Germanicus* was not a sharply defined coastline of the modern type. It was a broad, gradational **amphibious zone** comparable in character to analogs such as the Mississippi Delta, the Everglades, or the Pripyat Marshes: a vast, permanently or seasonally flooded floodplain and delta landscape with extensive reed beds, shallow lagoons, and a labyrinth of waterways.

Several evidence lines support this reconstruction. The peat stratigraphies of the classic fen areas — the Oderbruch, the Rhinluch, the Havelländisches Luch, the glacial valley near Eberswalde — preserve metre-scale peat layers resting directly on sand or lacustrine mud, recording long-lived reed-and-water-grass environments at or near a fluctuating shoreline. Such peat does not form in dry uplands; it forms where reeds, sedges, and rushes accumulate under permanently waterlogged conditions.

For an ancient observer approaching by boat from the north, no clear shoreline would have been visible. The horizon consisted of water and varying densities of vegetation, navigable in places with small boats but impassable to larger seagoing vessels. The strategic implication is significant: this zone constituted a formidable natural barrier against seaborne incursion from the north, providing *Germania Magna* with a defensive advantage that the Roman campaigns from the south never possessed on the northern side.

The zone also supported enormous biological productivity — fish, waterfowl, reed resources, peat, and rich organic sediment. Its ecological transformation following the 6th-century regression, from marine-influenced amphibious wetland to salinised dry plain and subsequently to fertile grassland, is directly documented by the palynological record (Section 7.4).

Section Summary: The Long Transgression

From the Stone Age (Blinkerwall, now 21 m below sea level, ≈9,000 yr BP) through the Bronze Age and Iron Age, a long, episodic Holocene transgression progressively submerged coastal and shelf areas of the southern Baltic, reducing the island of *Scandia* and generating demographic pressure culminating in the Gothic migration under Berig (associated with the Tollense conflict horizon, ≈1300–1250 BC). Episodic transgressive events, including the Cimbrian flood of the late pre-Roman Iron Age, represent discrete episodes within this long-term process. By Ptolemy's time (≈150 AD), the transgression had reached its Holocene maximum: the coastline at $\approx 52°50'$ N, with a broad amphibious buffer zone to the north of solid land.

4. The Ending of the Transgression: Crisis Events 525–536 AD

The long transgression was not reversed gradually. The available evidence points to its conclusion as a concentrated, catastrophic event cluster centred on approximately **525 to 536 AD**. Crucially, this falls *after* the publication of Ptolemy's geographical data — which still reflects the ancient, transgressive coastline — providing the physical explanation for why his data was already becoming geographically "inaccurate" even before medieval cartographers encountered it.

4.1 The Cosmochemical Record: GISP2 Ice Core Evidence

The most direct physical evidence for a cosmological component to the 536 AD crisis comes from the GISP2 Greenland ice core. Abbott et al. (2014), analysing particles from ice-core depths corresponding to 533–540 AD, document **four discrete chondritic and Sn-rich (tin-rich) cosmic spherule horizons** within this window.

The chemical characteristics of these particles are diagnostic of **cometary rather than asteroidal origin**:

- High carbon content (≈10–11 wt% C), consistent with primitive chondritic interplanetary dust and Halley-type material;
- Enrichment in highly volatile elements (I, Zn, Cu, Xe, sometimes Sn), characteristic of comets;
- Late-spring peak deposition seasonality, aligning with the Eta Aquarid meteor shower from Comet 1P/Halley;
- Associaton with tropical marine microfossils (*Thalassiosira oestrupii* diatoms, silicoflagellates) and aerosol-sized $CaCO_3$ crystals pointing to a low-latitude oceanic disturbance.

Four discrete chondritic horizons in a seven-year window are consistent with a **multi-fragment cometary delivery** — a scenario analogous to the sequential impacts of the disintegrated comet Shoemaker-Levy 9 on Jupiter in July 1994.

Comet 1P/Halley (perihelion 530 AD, one of the brightest on record) is the most plausible primary source. A Babylonian cuneiform record places a close Halley–Jupiter encounter in 164 BC that may have fragmented the comet into several larger pieces on divergent trajectories. A second candidate, comet C/539 W1 — a long-period body observed across Europe and Asia from 17 November 539 AD, with semi-major axis ≈ 91 AU (JPL Small-Body Database; Kronk, 1999) — has been linked by NASA and SETI Institute modelling to the irregular 15-Boötid meteor shower, raising the possibility of an independent fragmentation event.

4.2 Historical Sources on the Crisis Window

The historical record of 525–540 AD is exceptionally rich in geological, meteorological, and cosmic phenomena.

4.2.1 Michael the Syrian on the Year 525 AD

The World Chronicle of Michael the Great of Syria (Michael the Syrian, 12th c.) contains, for 525 AD, a passage of remarkable geological significance:

> *"In the year 836 of the Syrian era (525 AD) . . . a great flood came down from the mountains. It struck the city walls and receded. The second time, it tore down the walls, flooded the city, and killed people and animals by dragging them into the Euphrates . . . Thirty thousand dead were recovered from this flood, while the city's inhabitants estimated those missing in the waters at 200,000. . . . The earth spewed forth fire and water. Deadly vapours rose up . . . For a month and a half the earthquakes and the fiery rain continued without ceasing."*

The two-pulse flood pattern — striking the city walls, withdrawing, then striking again — physically describes a **seiche wave** (standing water oscillation triggered by tectonic disturbance) or a mega-flash-flood with rebound characteristics: not normal river flooding, but oscillatory wave behaviour. The simultaneous reports of "earth spewing fire and water," "deadly vapours," and the destruction of sites from Mesopotamia to Corinth suggest a continental-scale tectonic stress event.

Michael also records that "the waters of Shiloh disappeared for 15 years" from this date: disappearance of spring-fed water sources is a documented consequence of tectonic stress redistribution affecting fracture networks and karstic aquifer geometry.

The same chronicle continues with a passage of still greater geological significance:

> *"... A fifth earthquake shook the entire city, and all buildings, houses, palaces, and churches collapsed. A completely new phenomenon was observed, for the wind brought the punishment of Sodom. The river boiled over, and from the depths rose black waters that carried crabs, turtles, and the bones of wild animals. The earth spewed forth fire and water. Deadly vapours rose up, bringing death to men and animals through various sufferings. For several days it rained fire from heaven like rain. Everyone could hear the screams, but no one dared approach. For a month and a half the earthquakes and the fiery rain continued without ceasing. The great basilica that Constantine had built shook for seven days like a reed in the wind, until it cracked and fire rose up to burn the church. Only 1,250 souls survived these catastrophes.... "*

"Black waters" rising from the depths and carrying animal remains are consistent with a catastrophic eruption of gas and thermogenic fluid from a deep sedimentary or geological source — or with a massive flood surge carrying suspended dark organic material, such as a wave passing over a coal- or lignite-bearing formation. In the context of the Saale-Unstrut impact hypothesis developed in the companion preprint (Mildner, 2026a), it is specifically noted that an impact excavating the Geiseltal Eocene lignite and its fossiliferous horizons would have brought dark, carbon-rich water and fossil animal material (Eocene mammalian assemblage) to the surface — presenting themselves as the inexplicable "black waters" and "bones of wild animals" described by Michael the Great. Whether these remains represent excavated ancient fossils or contemporaneous fauna killed by the disaster cannot be resolved without systematic dating of the bone-bearing layer; both interpretations remain open. "The earth spewed forth fire and water" describes what is today recognisable as a **phreatic or hydrothermal eruption**: superheated groundwater flashing to steam and carrying volcanic or geothermal material to the surface. "Deadly vapours" is consistent with hydrogen sulphide or carbon dioxide release associated with volcanic or geothermal activity, or alternatively with cosmic-impact-triggered crustal gas release from disrupted sedimentary strata.

The **geographic spread of destruction** listed in the same source is also highly significant:

> *"Other regions were also destroyed: Seleucia in Syria by the sea, the city of Daphne, as well as an area of twenty miles around Antioch, Anazarbus, the metropolis of Cilicia, and Corinth, the metropolis of Greece."*

The simultaneous destruction of sites ranging from Mesopotamia (Edessa) through the Levantine coast (Seleucia), across the Anatolian interior (Anazarbus), and westward to mainland Greece (Corinth), all within a period spanning approximately a month and a half of "earthquakes and fiery rain," argues

4.2.2 Procopius of Caesarea on the Dimmed Sun

Procopius of Caesarea, *De Bellis* IV.14:

> *"The sun gave forth its light without brightness, resembling the moon, throughout this whole year, and it seemed exceedingly like the sun in eclipse, for the beams it shed were not clear. And from the time of this appearance men were free neither from war, nor pestilence, nor any other thing leading to death."*

Sustained solar dimming of a full year is incompatible with any single volcanic event (aerosols settle within 1–3 years) but consistent with the sustained loading projected from multiple successive injections of cometary dust, volcanic aerosols, and oceanic ejecta as documented by Abbott et al. (2014), Larsen et al. (2008), and Sigl et al. (2015).

A possible connection with the Norse description of a *Fimbulwinter* — three consecutive winters without an intervening summer — seems plausible in this context, as oral memory of the extended multi-year climate disruption that followed.

4.2.3 Cassiodorus on the Cold Summer (537 AD)

Cassiodorus (*Variae*, c. 537 AD) provides a precise Italian witness: *"The sun seemed to have lost its wonted light, and appeared of a bluish colour. We marvel to see no shadows of our bodies at noon, to feel the mighty vigour of its heat wasted into feebleness."* The observation that "no shadows were visible at noon" indicates strongly diffused rather than directional solar radiation — exactly the signature of a heavy stratospheric dust veil.

4.3 The Archaeological Settlement Hiatus

The most profound material evidence for the mid-6th-century catastrophe is the **settlement hiatus** documented across large portions of northern and central Germany.

Volkmann (2013, 2014) documents, for the region along the lower Oder and Warthe rivers, a progressive collapse of settlement density from the mid-5th century onward — "islands of remnant habitation" in an otherwise empty landscape by Stage E (6th century) — followed by complete absence in the 6th–7th centuries and renewed occupation only in the 8th century, then by Slavic-speaking arrivals. As Volkmann concludes: *"The findings point to drastic upheavals ... which in some cases occurred within just a few decades or even years ... [and] are not in line with a gradual transformation, but represent clear breaks in continuity through non-linear changes."*

Czerwiński et al. (2024) document from Brandenburg lake sediments a near-complete absence of settlement signals in the 6th–7th centuries, followed by Slavic recolonisation beginning around AD 670–700. The renewed opening of the landscape between approximately 510–650 and 650–780 AD coincides not with peak land use but with the recovery phase of the Late Antique Little Ice Age (Büntgen et al., 2016).

4.4 The Collapse of the Thuringian Kingdom (531 AD) and the *Barbarossa* Onomastic

The political collapse of the Thuringian Kingdom around 531 AD has long been attributed to Frankish military conquest. Bemmann (2023) has argued on archaeological grounds that this narrative is poorly supported: there were no Frankish military bases on strategically located heights, no demonstrable Frankish military presence in the material record, and no Frankish elite cemeteries in central Germany in the relevant horizon. Any putative Frankish garrison would, judging from cemetery sizes, have consisted of only a few men — "hopelessly outnumbered and without prospect of survival in a society without monopoly on violence." The geodynamic-impact framework proposed here supplies an alternative: the Thuringian Kingdom collapsed not primarily under Frankish military pressure but as a consequence of the environmental and demographic catastrophe that simultaneously emptied much of Central Europe and produced the climate anomaly Büntgen et al. (2016) call the Late Antique Little Ice Age.

Comets and the *Barbarossa* Onomastic. It is worth pausing, at this point in the argument, on a tentative onomastic remark that the present framework renders at least admissible. The medieval German appellation *Barbarossa* — documented in Italy in association with members of the Hohenstaufen dynasty before being attached canonically to Friedrich I (r. 1155–1190) — has long defied fully satisfactory etymological explanation. The name means literally "red beard" (*barba rossa* in Italian / Medieval Latin), and the physical trait has been taken as a biographical description. No certain alternative etymology exists.

Within the framework developed here, one may register the possibility — advanced as no more than a working speculation — that the name preserves a distant cultural memory of a fiery, red-bearded **cometary apparition** of precisely the kind that late-antique and early medieval chroniclers routinely described.

The connection between comets and the imagery of hair and beards is ancient and well documented. The very word 'comet' derives from the Greek *kome* (*κόμη*: hair), so that the Greek *kometes* (*κομήτης*) designates the 'long-haired star.' Pliny the Elder, in his *Naturalis Historia* (II.22.89–90), systematically classifies comets by their visual appearance, and among his explicitly named categories is the ***pogonias*** (*πωγωνίας*, from *πώγων*: beard) — the *'bearded comet,'* distinguished by a fiery ray or tail extending downward from the nucleus and resembling a flowing beard (Pliny the Elder, c. 77 AD). Medieval Latin chroniclers inherited and elaborated this vocabulary: comets appear in early medieval sources variously as *stella comata* (long-haired star) and *stella barbata* (bearded star), terms used with approximate interchangeability to denote threatening celestial visitors. Gregory of Tours, for example, records comets simply as exceptional lights in the sky accompanying disaster (Gregory of Tours, c. 575–594); the Carolingian annals note comets as *signa* preceding major upheavals.

A cometary apparition rendered particularly vivid — red or orange in colour from the atmospheric dust loading of the 530s, the very dust veil that Procopius describes as dimming the sun to the brightness of the moon — would, in the experience of survivors and their cultural descendants, have presented itself as a great red-bearded figure blazing across the sky. If this apparition was sufficiently dramatic and persistent to enter oral tradition, its cultural memory could survive, transformed across generations, as an epithet first of a catastrophe, then of a powerful figure associated with the recovery from that catastrophe. The subsequent Hohenstaufen association of the dynastic name with the recovery of German royal authority after the Investiture Contest — the reassertion of imperial power after a prolonged period of political breakdown — could plausibly have supplied the secondary semantic anchoring that transformed a cometary epithet into a dynastic surname.

It should further be noted that the comet of 530 AD (Halley's perihelion) was precisely contemporaneous with the fall of the Thuringian Kingdom and the events described by Gregory of Tours; and that comet C/539 W1 was observed, according to contemporary chronicles, as "exceptionally bright" over Europe and Asia from late November 539 AD (Kronk, 1999). The chronological proximity of these visible cometary apparitions to the collapse of political structures across Central Europe is thus documented, not merely hypothetical.

The proposal is offered here only to indicate the kind of additional cultural-memory layer that the framework, if correct, renders at least admissible. It is not advanced as a serious philological claim, and is set out only for completeness. That the very word 'comet' derives from the ancient perception of these bodies as long-haired or red-bearded celestial visitors (*pogonias* in Pliny) at least establishes the genuine antiquity of this metaphoric vocabulary in the tradition that subsequently produced medieval European culture.

4.5 The Palynological Record: Forest Destruction, Not Clearance

The palynological record provides decisive ecological corroboration of the catastrophic event model. The Migration-Period pollen record from northern Germany, the Netherlands, and Denmark shows, for ≈450–600 AD, an abrupt collapse of arboreal pollen (especially oak and beech) accompanied by a sharp rise in non-arboreal pollen of grasses and herbs. This has been classically interpreted as massive anthropogenic deforestation. The interpretation is irreconcilable with the contemporaneous settlement archaeology: the same period and regions show a sharp settlement break. No population was present to have done the supposed clearing.

The dominant reconciliation model — extensive pastoralism, with the vanishing population maintaining vast livestock herds that suppressed arboreal regrowth — fails on multiple counts. It cannot explain who managed the herds without infrastructure, provides no skeletal evidence for the animals, and requires a demographically collapsing population to have intensified land management.

Within the geodynamic-impact model, the contradiction dissolves: the abrupt arboreal pollen collapse marks the moment of the **firestorm** — the thermal pulse of an airburst or impact event, burning forests without any human involvement. The forest was not cleared; it burned. The subsequent rise of grasses and herbs is not pastoralism but the pioneer-phase signal of ecological succession on a salinised, eutrophicated, post-catastrophe surface. The specific botanical assemblage — halophytes far inland, continental steppe indicators (*Artemisia*), nitrogen-rich ruderal colonisers (Chenopodiaceae, Ellenberg N8–9) — is precisely the suite expected on a recently exposed, salt-affected, post-marine surface, not on grazed agricultural land (Ellenberg et al., 2010; Pott, 1995).

5. The Regression: Northward Coastline Shift After 536 AD

5.1 The Geodynamic Mechanism: CDF and TESZ Reactivation

The geodynamic mechanism proposed for the northward regression of the *Oceanus Germanicus* is a **late-stage reactivation of the Caledonian Deformation Front (CDF)** and the **Trans-European Suture Zone (TESZ)** under the compressional regime of the closing phases of Alpine convergence, catalysed by the cosmic and volcanic forcing of the 525–536 AD event cluster.

That the CDF is capable of repeated reactivation is established beyond question.

Deutschmann et al. (2018) identify **six polyphase reactivation episodes** since the Caledonian collision, demonstrating that this suture zone is a recurrently active structural weakness rather than an inert healed feature.

The mechanical sensitivity of the European intraplate domain to plate-boundary stress changes is quantitatively established by Nielsen et al. (2007), who demonstrate through elastic spherical-shell modelling that Africa-Europe convergence forces of order 3–4×10^{12} N m^{-1} can produce near-instantaneous, plate-wide responses. Lyngsie & Thybo (2007) document a 150-km-wide overthrust zone in which Avalonian upper crust was obliquely thrust over Baltica lower crust in a ramp–flat–ramp geometry — the structural template permitting renewed northward thrusting.

The proposed mechanism is a **renewed northward thrust of the Avalonian plate edge onto the Baltic plate**, producing:

- Lowering of relative sea level on the North German coast, exposing previously submerged amphibious-zone sediments;
- Uplift of Rügen and adjacent structures (eroded tip of the Avalonian leading edge);
- North–south crustal shortening, contributing to Erzgebirge uplift and documented graben structures;
- Exposure of the former amphibious zone as it drained over subsequent decades.

A simple volumetric check confirms physical plausibility. A northward retreat of ≈ 120 km along a 400-km coast with average former seafloor elevation $\bar{h} \approx 7.5$ m implies a sediment exposure volume of:

$$V_{\text{required}} = 400 \times 120 \times 0.0075 = 360 \text{ km}^3 \approx 13\% \, V_{\text{Storegga}} \tag{3}$$

This represents only $\approx 13\%$ of the Storegga Slide volume (Weninger et al., 2008), well within the range of a single major compressional-foreland sediment redistribution event.

5.2 Post-Antique Natural Catastrophes: Tectonic Settling and Crustal Readjustment

A major geodynamic event does not end cleanly. The displaced and re-stressed crustal blocks undergo prolonged **post-event settling and readjustment**: sequences of stress relaxation, aftershock activity, secondary fault reactivation, and hydrological responses continuing for decades or centuries. The following medieval chronicle sources document precisely this kind of prolonged seismic tail following the main 6th-century event.

5.2.1 Gregory of Tours (Historia Francorum): A Catalogue of Disturbed Earth

Gregory of Tours (c. 538–594 AD), bishop of Tours from 573, wrote his *Decem libri historiarum* over the last two decades of his life. The work contains, scattered through its political narrative, a remarkable series of natural disaster reports spanning approximately 563–594 AD — exactly the period of predicted post-event seismic settling.

The Tauredunum Event (563 AD) (*Historia Francorum* IV.31): Gregory describes in precise detail a massive slope failure above the Rhône valley that had been preceded by sixty days of rumbling, then catastrophically collapsed:

> *"A great prodigy occurred in Gaul at the town of Tauredunum, situated on the Rhône. After a sort of rumbling had continued for more than sixty days, the mountain was finally torn away and separated from another mountain near it, together with men, churches, property and houses, and fell into the river; and the banks of the river were blocked and the water flowed back ... The gathered water burst its way downstream and took men by surprise ... It is told by many that the mass of water was so great that it went over the walls into the city [of Geneva]."*

This combines prolonged seismic precursor activity (sixty days of rumbling), massive slope failure, river blockage, and a downstream tsunami-like flood wave. The 27-year gap between the 536 AD main event and the Tauredunum collapse is entirely consistent with long-timescale slope-stability degradation in an alpine zone of elevated post-event seismicity.

The Bordeaux Earthquake and Gallic Floods (580 AD) (*Historia Francorum* V.33): Gregory records, for ≈580 AD, a violent earthquake at Bordeaux that "seemed to threaten the city with ruin," its tremor extending to neighbouring cities and reaching as far as Spain. Simultaneously: twelve days of exceptional rain in the Auvergne flooded the Limagne plain; the Loire, Allier, and other rivers overflowed beyond remembered limits, destroying livestock, crops, and buildings; the Rhône and Saône overflowed and damaged the walls of Lyon; and in the Pyrenees, "huge stones were dislodged, crushing livestock and people."

A major earthquake centred near Bordeaux, felt as far as Spain, with simultaneous Massif Central flooding and Pyrenean rockfalls, is consistent with a significant seismic event in the Iberian–European convergence zone, potentially reflecting ongoing stress redistribution in the western European plate approximately 44 years after the main CDF reactivation.

The Prodigy Catalogue of 587 AD (*Historia Francorum* IX.5): Gregory records for 587: "Rays of light were seen in the north ... it is reported from hearsay that snakes had fallen from the clouds, and that a village with its inhabitants and dwellings had disappeared entirely." Rays of light in the north (possible aurora from residual geomagnetic disturbance), and a village disappearing wholesale (ground subsidence or liquefaction), add further entries to the distributed catalogue of post-event geological disruption.

The Tiber Flood and Rome Earthquake Cluster (589–590 AD) (*Historia Francorum* X.1, X.23): The catastrophic Tiber flood of 589 AD — independently documented in multiple contemporary sources, which record the river carrying "a multitude of serpents" and unusual detritus — and a major felt earthquake on 14 June 590, accompany the reign of Gregory the Great at the beginning of his pontificate. Combined with the Tauredunum (563) and Bordeaux (580) events, these form a distributed sequence of major geological disruptions spanning 563–590 AD — a 27-year post-event seismic tail precisely consistent with the geodynamic model's predictions.

5.2.2 The Royal Frankish Annals (Annales regni Francorum)

The *Annales regni Francorum* (covering 741–829 AD) (Royal Frankish Annals, 1972) are primarily political and military records, but several entries document geological and hydrological disruptions:

s.a. 784–785: Exceptional flooding (*nimiam inundationes aquarum*) disrupted Charlemagne's Saxon campaigns in successive years, forcing route changes and early withdrawals from the Weser region. Exceptional flooding across multiple drainage systems in the same years points to hydrological conditions well outside normal range.

s.a. 801: Multiple primary and secondary sources record a major earthquake on 30 April 801 causing building damage across northern Italy and southern Germany — approximately 265 years after the 536 AD main event, consistent with a stress-relaxation cycle on a reactivated fault system.

s.a. 823: "Numerous settlements destroyed by fire from heaven (*ignis de caelo*) in Saxony." Spatial extent over multiple settlements suggests a phenomenon beyond normal lightning-induced fire; it adds to the continuing catalogue of anomalous events in the CDF zone.

5.2.3 The Annales Bertiniani: Continuing Anomalies (830–882 AD)

The *Annales Bertiniani* (Annals of Saint-Bertin, 830–882 AD) (Nelson, 1991) extend the Frankish annalistic record into the 9th century with several entries relevant to ongoing tectonic settling:

s.a. 849: An earthquake in the Mainz/Worms region — precisely in the zone of the Main-valley tectonic complex that the present model identifies with the late-tectonic deformation of the *Abnoba Mons* / Taunus block.

s.a. 855: Observation of "two stars moving across the sky from west to east, alternating in visibility, up to ten times." This observation — whatever its physical explanation — is consistent with continuing presence of anomalous material in the near-Earth environment during the centuries following the 536 AD cometary event cluster.

s.a. 863 and 876–877: Further earthquake and storm reports in West Francia, in the continuing catalogue of post-event geological disruption.

Taken as a whole across the period 530–880 AD, the Frankish annalistic tradition documents a sustained series of seismic, hydrological, and atmospheric events whose spatial and temporal clustering is consistent with **prolonged post-event tectonic settling** in the Central European region following the 525–536 AD main event. No single entry is conclusive individually; in aggregate they constitute a body of evidence for ongoing geological instability spanning approximately three centuries.

5.2.4 Historical Seismicity of the Erzgebirge and the 2024 Herzberg Earthquake

Meier (1998) documents a historical catalogue of earthquakes in the Erzgebirge region of Saxony, demonstrating that this zone has experienced repeated seismic events across historical time. The region's seismicity aligns with the geodynamic model: the Erzgebirge block, interpreted as a tectonic fault-block mountain range that experienced relative uplift following CDF reactivation, would be expected to produce stress-relaxation events over extended periods.

The instrumentally recorded M_L 3.1 earthquake of 18 October 2024 near **Herzberg/Elster and Doberlug-Kirchhain** (hypocentre depth $\approx$ 21 km) provides a modern analogue: a lower-crustal event with no prior seismicity in the instrumental catalogue, in a location that the block-rotation model independently identifies as a residual stress concentration zone. The predicted second ellipse focus (F_2) of the compressed meander structure lies within $\approx$ 16.9 km of the epicentre, within combined model and localisation uncertainty. The historical Herzberg chronicle records a macroseismic event in 1483 (intensity $\approx$IV, church tower collapse, urban fire): the interval 1483–2024 = 541 years is consistent with a residual stress accumulation cycle driven by Africa–Europe convergence.

5.3 The Medieval Cartographic Error: How the Coastline Shift Produced False Geography

By the time Ptolemy's *Geographike Hyphegesis* was rediscovered and re-edited in the 15th century, the regression of the 6th century was approximately 900 years in the past. The coastline had moved 120 km northward. Medieval scholars who identified Ptolemy's *Oceanus Germanicus* coastline with the Baltic and North Sea coasts as they actually knew them were making the only identification their methodology permitted. They had no way of knowing the coastline had changed; their experience showed a stable Baltic shore. They projected Ptolemy's coordinates onto the existing coastline as their northern reference, and all subsequent distortions followed necessarily.

This is not a failure of medieval scholarship; it is the inevitable consequence of projecting ancient data onto a transformed landscape without the conceptual tools to recognise the transformation. The medieval cartographers were as competent as their methodology allowed. The problem was that the accumulated geographic tradition from late antiquity to the 15th century contained no memory of the catastrophic landscape transformation that had intervened. That memory had been preserved only in fragmentary chronicles, mythological traditions (*Fimbulwinter*, *diluvium peccati*, *Vineta*), and geological landforms that no one in 1482 had yet learned to read.

5.4 The Loss of Toponymic Continuity and Slavic Resettlement

Between the departure of Germanic populations from the *Germania Magna* zone (complete by ≈7th century) and the Slavic colonisation (primarily 8th century onward), the territory passed through a settlement discontinuity of at least one to two human generations. In this interval, the oral traditions that maintained local toponyms were broken.

The rivers, mountains, and settlements of Ptolemy's *Germania Magna* had names in 150 AD. The Germanic peoples who inhabited the region maintained these names in oral tradition. When those peoples departed, the names were lost. The Slavic colonists who arrived subsequently found an empty landscape and gave it new names. When medieval scholars projected Ptolemy's ancient names onto the now-Slavicised landscape, they could not find the ancient referents and therefore pushed their search eastward until they found equivalent-seeming features: the ancient *Vistula Fluvius* of the Lusatian system became attached to the large river in Poland that superficially resembled it in size.

Cosmas of Prague (early 12th century) preserves the cultural memory of the catastrophic depopulation in his description of a *diluvium peccati* — a "flood of sin" — that had once "deprived the land of its inhabitants." Whether theological metaphor, historical memory of flooding, or both, it stands as evidence that the memory of catastrophic depopulation survived in cultural tradition even after the details had been transformed into religious allegory.

Section Summary: The Regression

The events of 525–536 AD — documented by GISP2 cosmochemistry, Byzantine and Syrian chronicles, dendroclimatology, and the archaeological hiatus — terminated the long transgression via late-stage CDF/TESZ reactivation, shifting the *Oceanus Germanicus* coastline approximately 120 km northward. Post-event tectonic settling is independently documented by Gregory of Tours (Tauredunum 563, Bordeaux earthquake 580, Tiber flood 589), the Royal Frankish Annals (major earthquake 801, "fire from heaven" 823), and the *Annales Bertiniani* (Rhine-zone earthquake 849). Loss of toponymic continuity during the 6th–7th century settlement hiatus produced the medieval eastward projection of the *Vistula Fluvius* name onto the Polish Vistula.

6. The Geodynamic Framework

6.1 The CDF and TESZ: Architecture and Reactivatability

The **Caledonian Deformation Front (CDF)** marks the ancient collision boundary between Avalonia and Baltica, sutured $\approx$ 420–450 Ma during the Caledonian orogeny. As part of the broader **Trans-European Suture Zone (TESZ)** (Pharaoh, 1999), it extends as a complex, approximately 200–400-km-wide lithospheric discontinuity from east of the Shetlands across the North Sea through Denmark and northern Germany, continuing as the Teisseyre-Tornquist Zone into Poland and Ukraine. Its key mechanical properties for the present model are:

- **Reduced effective cohesion**: prior deformation and fluid infiltration have lowered frictional strength on fault planes throughout the zone;
- **Polyphase reactivation history**: Deutschmann et al. (2018) document six reactivation episodes since the Caledonian collision — demonstrating a recurrently mobilisable structural weakness, not a healed suture;
- **Sensitivity to far-field stress**: Nielsen et al. (2007) demonstrate that plate-scale Africa-Europe compressive stresses ($3\text{–}4 \times 10^{12}\ \mathrm{N\,m^{-1}}$) can drive CDF reactivation plate-wide and near-instantaneously, without mantle-plume involvement;
- **Ramp–flat–ramp overthrust geometry**: Lyngsie & Thybo (2007) image a 150-km-wide zone in which Avalonian upper crust was obliquely thrust over Baltica lower crust — the template for renewed thrusting.

Thybo & Nielsen (2012) further document a gabbroic batholith of at least 60,000 km^3 beneath the Danish Basin, providing additional evidence for the complex, episodically active deep crustal architecture of the CDF zone.

6.2 Block Rotation About the Lusatian Anchor

The **Lusatian Granodiorite Block** (Neoproterozoic–Cambrian, 505–520 Ma) acts as a rigid kinematic anchor: too competent to deform internally, it rotates about its margins under the compressional CDF reactivation regime, imparting characteristic curvatures to surrounding sedimentary sequences.

The four Ptolemaic place names of the "Elster Cluster" — *Budorigum* (Doberlug-Kirchhain), *Limis Lucus* (Baruth/Mark), *Lugidunum* (Falkenberg/Elster), and *Stragona* (Herzberg/Elster) — show a highly significant **systematic eastward displacement** of $\overline{\Delta\lambda} = -93.1$ km relative to the affine model prediction ($t = -13.7$, $p < 0.001$, $df = 3$). The low standard deviation ($\sigma_{\Delta\lambda} \approx 13$ km, only $\approx 14\%$ of the mean shift) indicates *rigid block kinematics*, not random noise.

For a dextral rotation about the Senftenberg pivot (13.97° E / 51.54° N) with mean lever arm $\bar{R} \approx 138$ km:

$$\alpha = 2 \arcsin\left(\frac{93.1}{2 \times 138}\right) \approx 39.3^\circ \quad \text{(dextral, clockwise)} \tag{4}$$

The **Elbe Lineament** (Elbezone), an $\approx$ 500-km-long NW–SE-striking crustal discontinuity, served as the primary transmission channel for this rotation: its NW-SE orientation is nearly perpendicular to the eastward displacement vector, geometrically optimal for dextral transpressive rupture in a Riedel shear geometry.

The **anthracite deposit at Doberlug-Kirchhain** provides independent geochemical cross-validation: near-surface anthracite is anomalous for standard burial-depth curves and is interpreted as **stress metamorphism** at the shear-zone upper boundary. Two entirely independent evidence lines — cartometric residual and coal petrology — converge on the same geographic point.

6.3 Triggers: Cometary, Volcanic, and Tectonic Cascade

The geodynamic framework is robust to the precise trigger mechanism. Three admissible classes have been discussed:

1. **Endogenic stress relaxation**: slow loading from ongoing Africa-Europe convergence and glacio-isostatic rebound, episodically released;
2. **Volcanic forcing**: the 536 and 540 AD eruptions (Larsen et al., 2008; Sigl et al., 2015; Toohey et al., 2016) contributed atmospheric loading and possible seismic coupling;
3. **Cometary impact or airburst** (Abbott et al., 2014): GISP2 documents four discrete chondritic particle horizons in 533–540 AD. A Shoemaker-Levy-9-type multi-fragment cometary train is the most parsimonious interpretation.

A fourth, more speculative possibility is an impact on the southern margin of the African plate contributing an impulsive acceleration to Africa-Europe convergence (Allan & Delair, 1997); this is not required by the model but cannot be excluded.

The most physically economical scenario is a **cascade trigger**: a lithosphere pre-loaded to near-failure by accumulated Africa-Europe compressive stress, pushed into failure by the additional impulsive stress of one or more cometary impacts or airbursts at approximately 530–531 AD, with the resulting tectonic cascade driving both the block rotation of the Elster-Lusatia domain and the northward thrust of the Avalonian plate edge.

6.4 The Český Kráter as Possible Impact Structure

The **Český Kráter** (Rajlich, 1992, 2007) (Rajlich, 2007) is a multi-ring astrobleme structure in the Bohemian Massif with outer ring scar up to 600 km, inner crater ≈ 300 km, Moho depression ≈ 40 km, and abundant shock evidence (pseudotachylite breccia veins, PDFs in quartz, microdiamonds, moissanite, coesite). Its conventional Palaeoproterozoic (≈ 2 Ga) radiometric age is explained in Section 6.5.

The **Saale-Unstrut Fragment Impact Hypothesis** developed in the companion preprint (Mildner, 2026a) postulates that a cometary fragment struck the Saale-Unstrut Triassic Lands zone (postulated centre: Geiseltal-West, ≈ 11.73°E / 51.33°N) in approximately late 530 or early 531 AD, acting as a cascade trigger within the biaxial structural stress field defined by the Bramsche Pluton axis (NW, 8.00°E / 52.42°N) and the Český Kráter zone (SE, ≈ 14.67°E / 49.42°N). The biaxial loading between these boundary structures pre-loads the intervening Saale-Unstrut zone to within ≈ 5 MPa of the Coulomb failure threshold — requiring only a modest cascade trigger to nucleate block displacement.

6.5 A Methodological Note on Impact-Structure Dating (Age Inheritance)

The apparent Palaeoproterozoic age of the Český Kráter does not constitute decisive evidence against a younger geodynamic event. Zircon ($ZrSiO_4$) is among the most refractory minerals known, with closure temperatures far exceeding those reached in most impact melts. When a cometary fragment strikes a basement composed of ≈ 2 Ga Bohemian crystalline rocks, the great majority of pre-existing zircons survive intact as inherited xenocrysts within the new impactite. Radiometric dating then measures the age of the *target rocks*, not the age of the impact.

Detection of a younger event age requires specifically targeted SHRIMP or laser-ablation analysis of shock-recrystallised zircon domains and melt-glass matrix phases — methods that have not yet been applied to the Český Kráter with this explicit aim. This consideration is noted not to defend any specific chronological assignment, but to clarify what the standard radiometric arguments can and cannot demonstrate.

6.6 Kaolin Deposits as Radial Far-Field Evidence

A striking non-random pattern in the distribution of Central European kaolin deposits provides indirect but potentially significant evidence for the Bohemian Massif ring system. Kužvart (1992) documents strong spatial clustering in the Bohemian Massif and its northern margins (Karlovy Vary, Ore Mountains, Meissen area, Upper Lusatia including Caminau). Götze et al. (2023) provide detailed evidence from the Kemmlitz rhyolite (NW-Saxonian Basin) that agate formation involved hydrothermal fluids at temperatures exceeding 150°C — far above what surficial weathering can achieve — with trace-element signatures (B, Ge, U; anomalous REE) consistent with magmatic-hydrothermal genesis (Seyhan, 1971).

A binomial test on the distribution of 14 major Central European kaolin deposits relative to the Český Kráter ring system yields: 13 of 14 deposits within the farthest documented Rajlich ring ($r \approx 270$ km, $p \approx 3.4 \times 10^{-5}$), highly significant at $p \ll 0.001$.

6.7 Coal Deposits as Stress-Metamorphic Evidence

Anomalously shallow high-rank coal and anthracite occurrences in the region between the Saale-Unstrut impact zone and the Český Kráter outer rim — Doberlug-Kirchhain anthracite (≈ 66 km ENE of the SU outer rim), Lugau-Oelsnitz hard coal (≈ 100 km SSE of the SU outer ring, precisely in the biaxial corridor between both impact zones), and the Freital/Döhlen Basin (≈ 240 km from the CK centre) — define a spatially coherent NW–SE belt in the zone of predicted maximum biaxial stress overlap. These deposits may record **stress metamorphism** from impact-generated shock waves, providing the mechanical energy equivalent to the deep-burial thermal maturation normally required for high-rank coalification.

7. The Event-Dark-Earth Hypothesis

7.1 The Stratigraphic Problem

Dark Earth layers — thick, dark-brown to black, structurally homogeneous soil horizons (commonly 0.2–1.0 m) between Late Antique and High Medieval strata — are widespread in European excavations. The catalogue of Gaberz (2014) documents the phenomenon at numerous sites and identifies the following problematic features that resist the standard gradualist explanation (bioturbation, horticulture, ruralisation):

1. Extreme homogeneity without internal stratification, despite coarse clasts (bricks, rubble) that should sort;
2. Vitrified material requiring 1200–1500°C — incompatible with domestic hearths;
3. Near-synchronous deposition across geographically dispersed sites in the same chronological window;
4. Simultaneous collapse and non-rebuilding of built structures;
5. Persistent lack of datable material within the horizon.

The gradualist model faces a fundamental logical difficulty: it requires the very population whose absence defines the horizon to have been producing that horizon through intensive activity. A vanishing population cannot simultaneously be massively modifying the landscape through charcoal production and levelling.

7.2 The Event-Deposit Reinterpretation and ED-E Subclass

The **Event-Dark-Earth (ED-E)** hypothesis proposes that a chronologically restricted subset of Dark Earth records represents the material product of a sudden, high-energy depositional event: the combined action of a thermal pulse (firestorm from airburst or impact origin) and a subsequent flood pulse (tsunami, hydrometeor, or lahar equivalent), subsequently homogenised by post-depositional bioturbation. The vitrified materials are reinterpreted as *impactites* or clay/brick fired *in situ* by the thermal pulse, consistent with the occasionally documented occurrence of vitrified stonework on early medieval ringforts (Vitrified Forts of Scotland and Ireland).

7.3 Falsifiable Predictions for the ED-E Horizon

Six specific falsifiable predictions distinguish an ED-E layer from normal Dark Earth:

P1. **Chaotic homogeneity**: no internal lamination or hydrodynamic sorting, despite coarse clast inclusion;

P2. **Geochemical anomalies**: elevated Cl/Br ratios (marine injection), elevated PAH (high-T combustion), cosmochemical markers (Ir, Ni, chondritic spherules);

P3. **Heavy-mineral basal enrichment** ("soap effect"): hydraulic sorting by a single high-energy flood pulse;

P4. **Micromorphological impulsive mixing fabric**: distinguishable from gradual earthworm-reworking fabrics;

P5. **In-situ thermal anomalies**: vitrification or flash-heating signatures incompatible with domestic hearths;

P6. **Synchronous abrupt tree-pollen collapse** without crop-pollen increase — distinguishable from gradual anthropogenic clearing.

7.4 Palynology as Ecological Witness

Czerwiński et al. (2024) provide the most recent high-resolution palynological support. Their Brandenburg lake sediment data document near-complete absence of settlement signals in the 6th–7th centuries, post-catastrophic landscape opening consistent with non-anthropogenic disturbance, and delayed Slavic recolonisation beginning ≈670–700 AD when environmental recovery had sufficiently advanced.

The specific botanical assemblage of the palynological hiatus — halophytes inland, continental steppe indicators (*Artemisia*), nitrogen-rich eutrophication indicators (Chenopodiaceae, Ellenberg N8–9) — is the ecological fingerprint of a recently exposed, salt-affected, post-marine surface, not of grazed agricultural land (Ellenberg et al., 2010; Pott, 1995).

7.5 Post-Catastrophic Ecological Succession and Slavic Settlement

The sequence of ecological recovery provides the context for both the pollen record and the historical narrative of resettlement:

Years 0–5 (≈530–535 AD): Moonscape of ash, fire debris, tsunami sediment. Soil salt-saturated; no vegetation; no human presence.
Years 5–30 (≈535–560 AD): Halophytic pioneers colonise exposed saline surface. Barren steppe landscape. Slavic-speaking and Avar horse-peoples advance westward into what was formerly impenetrable forested *Germania Magna* but is now open grassland.
Years 30–80 (≈560–610 AD): Rain leaches salt; birch, poplar, hazel pioneers return. Savanna-like landscape. First permanent agricultural resettlement feasible — Cosmas of Prague's *Boemus* finding open land ready for farming without forest clearance.
Years 80–150 (≈610–680 AD): Oak and beech return on phosphate-rich ED-E substrate, producing characteristically dense forest — the *Miriquidi* of Thietmar of Merseburg (≈1000 AD).

8. *Scandia* / Skandza: The Southern Baltic Island Massif

8.1 Ptolemy's Coordinates for *Scandia*

In *Geographia* II.11, Ptolemy places the *Scandian islands* east of the Cimbrian Peninsula (Jutland), with the largest and most easterly — which he specifically calls *Scandia* — situated "at the mouth of the Vistula River." In the reidentification proposed here, the *Vistula Fluvius* mouth lies in the Oderberg area at ≈ 52°50′ N. The island lying at or opposite this mouth falls in the area of the present-day Usedom/Wolin archipelago — more precisely, in the broader shelf zone of Mecklenburg-Vorpommern and Western Pomerania that, in Ptolemy's time, still largely emerged above the amphibious coastal zone as a defined island complex.

8.2 Why Scandinavia Cannot Be *Scandia*

The conventional identification of Ptolemy's *Scandia* with the Scandinavian Peninsula confronts two decisive objections:

Demographic: Jordanes describes the migration as driven by *vagina nationum* pressure — the island could no longer sustain its population. This is implausible for the vast territories of modern Norway and Sweden; it is compelling for a limited southern-Baltic island progressively reduced by marine transgression.

Cartometric: Ptolemy places *Scandia* "at the mouth of the Vistula River." The modern Polish Vistula mouth is in the Gulf of Gdańsk, ≈ 400 km from Norway and Sweden — impossible to describe as "at or opposite" the river mouth in any plausible geographic sense. Under the Lusatian *Vistula Fluvius* reidentification, the relationship is immediately comprehensible: the island lies north of the Oderberg mouth, visible from both sides.

8.3 The Blinkerwall and the Long Prehistory of Land Loss

The Blinkerwall evidence carries a specific implication for *Scandia*: the southern Baltic shelf was substantially larger in the Stone Age, providing the maximum-extent territory from which millennia of progressive transgression subsequently reduced the land available to the island's inhabitants. The territorial contraction was not abrupt; it was experienced progressively over generations as a slow but inexorable shortening of the habitable world. The *vagina nationum* mythology reflects a cultural memory of this long process, not a sudden crisis.

8.4 *Scandia*, *Vineta*, and the Varangians

The ancient name *Scandia* may connect to the legendary *Vineta* — the sunken city of the Baltic, said to lie somewhere on the southern Baltic coast. The legend consistently places it in the Wolin/Usedom area, precisely the zone identified here as the ancient *Scandia* location. The structural parallel with the Atlantic tradition (a prosperous island civilisation lost beneath the sea) is striking; in both cases the physical mechanism may have been progressive marine transgression, remembered culturally as catastrophic submersion.

The possible connection between *Scandia* and the **Varangians** — the Norse maritime trading and raiding class of the Baltic — is also worth noting. If ancestral Norse seafaring culture developed not on the Scandinavian mainland but on a progressively shrinking southern Baltic island complex, the maritime orientation is immediately comprehensible: seafaring was a survival necessity, not a cultural option, for a people whose homeland was literally shrinking beneath them.

9. Archaeological and Demographic Consequences

9.1 Settlement Patterns of the Migration Period

The Migration Period archaeology of Central and Northern Europe has long been characterised by two seemingly contradictory features: evidence of large-scale population movement, and widespread settlement vacuum. The distinction in the present model lies in separating the long-term transgression-driven migrations (Bronze Age through Roman times) from the catastrophic emptying of the landscape in the 6th century AD.

The Roman Iron Age saw intensive Germanic settlement across *Germania Magna* — the *Odergermanische Gruppe* (Volkmann, 2013) among other regional cultural complexes. From the mid-5th century, this landscape began to contract progressively; by the 6th century, the contraction had become a collapse: wholesale abandonment of zones continuously occupied for centuries. The settlement vacuum is not difficult to explain within the catastrophe model: the event killed or dispersed the existing population, rendered the landscape temporarily uninhabitable, and prevented resettlement until ecological recovery had sufficiently advanced.

9.2 Maritime Cultures and the *Oceanus Germanicus*

The long transgression generated, on the island groups and semi-submerged coastal zones of the ancient amphibious belt, a population well adapted to maritime conditions. The expansionary pressure of the Roman Empire, which may have pushed Germanic coastal groups northward onto the islands, combined with the progressive loss of mainland territory to marine transgression, to produce the maritime orientation that would eventually characterise the Vikings and their ancestors. On the island groups of northern *Germania Magna*, Nordic seafaring peoples — ancestors and relatives of the Vikings — may have first developed their distinctive maritime culture, perhaps partly under expansionary pressure from the Roman Empire, perhaps because they had already lost mainland settlements to the progressive transgression.

9.3 Ship Finds in Former Amphibious Zones

Several ship finds in what is now mainland Mecklenburg-Vorpommern, including the so-called Usedom boat graves (Biermann, 2004), have conventionally been interpreted as deliberate boat burials. The present model suggests a complementary possibility: at least some may be the remains of vessels lost in battle or catastrophe in what was at the time shallow water, and subsequently incorporated into the sedimentary record as the amphibious zone drained following the regression. Future excavation strategies in the former amphibious zone should consider this alternative depositional context, particularly where find horizons show evidence of rapid, high-energy burial rather than careful deliberate interment.

10. Discussion: Convergent Lines of Evidence

The argument developed in this paper integrates evidence from eight independent research domains. No single line is conclusive in isolation; their mutual reinforcement across independent methodologies creates a cumulative case substantially more powerful than any individual component.

10.1 Cartometric Evidence

The affine transformation with $k \approx 28$ km/°, anchored on the Rhine–Elbe baseline, places the ancient coastline ≈ 120 km south of its modern position. The statistically irrefutable Elster Cluster displacement ($\Delta\lambda = -93.1$ km, $t = -13.7$, $p < 0.001$) confirms a real tectonic block shift superimposed on the coastal projection error. The independent convergence of the cartometric *Budorigum* identification with the stress-metamorphic anthracite anomaly at Doberlug-Kirchhain provides one of the methodologically most robust cross-validations in the framework.

10.2 Geological and Mineralogical Evidence

Deep-seismic evidence (Lyngsie & Thybo, 2007; Deutschmann et al., 2018; Thybo & Nielsen, 2012) firmly establishes the mechanical architecture and polyphase reactivation history of the CDF. The plate-stress transmission modelling of Nielsen et al. (2007) provides the quantitative framework for far-field activation. The kaolin clustering statistics (13/14 deposits within $r < 270$ km of the Český Kráter centre; $p \approx 3.4 \times 10^{-5}$) and the hydrothermal mineralogy documented by Götze et al. (2023) indicate an active deep hydrothermal system in the Bohemian Massif ring zone. The anomalous Quaternary subsidence documented by Arfai et al. (2018) ($\geq 10\times$ Cenozoic average; 180 m unexplained residual) provides independent evidence for anomalous recent geological dynamics in the North Sea zone.

10.3 Cosmochemical and Climatological Evidence

Four discrete chondritic particle horizons in GISP2 for 533–540 AD (Abbott et al., 2014) provide the most direct physical evidence for an extraordinary extraterrestrial contribution. Their cometary chemical signatures, combined with the Late Antique Little Ice Age (Büntgen et al., 2016), the volcanic double event of 536–540 AD (Sigl et al., 2015; Toohey et al., 2016), and the independently documented comet C/539 W1 (Kronk, 1999), establish a multi-forcing character for the 6th-century environmental crisis.

10.4 Historical Sources

The historical documentation of the crisis window is remarkably wide and geographically diverse: Michael the Syrian (525 AD; Edessa flood, Antioch earthquake, fire from heaven), Procopius (dim sun, 536 AD), Cassiodorus (cold summer, 537 AD), Gregory of Tours (Tauredunum 563, Bordeaux 580, Tiber flood 589), Royal Frankish Annals (earthquake 801, fire from heaven 823), and *Annales Bertiniani* (earthquakes 849, 863). Together, these form a chronicle spanning 525–880 AD of converging geological, meteorological, and astronomical anomalies consistent with one major geodynamic event and its prolonged tectonic settling phase.

10.5 Archaeological Evidence

The settlement hiatus (Volkmann, 2013, 2014; Bemmann, 2023; Czerwiński et al., 2024) — rapid, geographically comprehensive, without the expected Frankish military traces — is not explicable by migration alone or by political conquest. It is the signature of a landscape-transforming catastrophe. The fact that Slavic resettlement proceeded into what was evidently an open, lightly vegetated landscape (implied by rapid advance and by the pioneer-species pollen signal) provides the ecological context for understanding why resettlement was possible at all.

10.6 Ecological Evidence

The palynological assemblage of the hiatus — halophytes inland, continental steppe indicators, nitrogen-rich ruderal colonisers, Ellenberg N8–9 (Ellenberg et al., 2010) — is the specific ecological fingerprint of a recently exposed, salt-affected, post-marine surface: not a vague compatibility with a catastrophe model, but a positive identification of the expected ecological suite.

Table 1: Independent lines of evidence converging on a catastrophic Central European environmental event in the window c. 525–550 AD.

Evidence category	Principal source	Observation
Cosmochemistry	GISP2 ice core (Abbott et al., 2014)	Four discrete chondritic / Sn-rich particle horizons, 533–540 AD
Astronomical	Comet C/539 W1 (Kronk, 1999); Halley (530 AD)	Major comets observed across Europe and Asia; possible Venus-perihelion fragmentation
Volcanic forcing	Ice cores (Larsen et al., 2008; Sigl et al., 2015; Toohey et al., 2016)	Major eruptions 536 and 540 AD
Dendroclimatology	Tree-rings (Büntgen et al., 2016)	Northern Hemisphere cooling, 536 to c. 660 AD (Late Antique Little Ice Age)
Byzantine chronicle	Procopius, *De Bellis* IV.14	Sun "without rays, like the moon"
Italian chronicle	Cassiodorus, *Variae*	"Summer without heat"; anomalous solar dimming
Syrian chronicle	Michael the Syrian (Michael the Syrian, 12th c.)	Edessa flood; Antioch earthquake; fire from heaven; black flood waters
Frankish chronicles	Gregory of Tours (Gregory of Tours, c. 575–594); Royal Frankish Annals (Royal Frankish Annals, 1972); *Ann. Bertiniani* (Nelson, 1991)	Tauredunum 563; Bordeaux earthquake 580; Tiber 589; earthquakes 801, 849; fire from heaven 823
Palynology	Brandenburg lake sediments (Czerwiński et al., 2024)	Settlement-pollen collapse, 6th c.; Slavic recolonisation from ≈670–700 AD
Settlement archaeology	Volkmann (2013, 2014); Bemmann (2023)	Settlement hiatus, 5th–7th c., across Lower Saxony, Mecklenburg, Thuringia
Political history	Gregory of Tours; Bemmann (2023)	Collapse of Thuringian Kingdom 531 AD; absence of expected Frankish occupation
Ecological succession	Ellenberg et al. (2010); Pott (1995)	Halophyte–steppe pioneer assemblage on post-marine surface
Folklore and myth	*diluvium peccati* (Cosmas of Prague); Norse *Fimbulwinter*	Cultural memory of catastrophic depopulation and extended cosmic winter

11. Methodological Status and Falsification Pathways

The framework is explicitly formulated as a falsifiable working hypothesis, not a definitive reconstruction. Specific falsification pathways:

T1 (Geochronological, decisive): SHRIMP or laser-ablation dating of shock-recrystallised zircon domains and melt-glass matrix phases in Český Kráter breccias, specifically targeting impact-generated rather than inherited populations. Holocene or Late Antique age would substantially confirm; purely Proterozoic age (unlikely given age-inheritance argument) would constrain.

T2 (Sedimentological): High-resolution chronostratigraphy of coastal peat sequences in NE Germany, examining whether the peat-to-sand transition in the former amphibious zone is rapid and dateable to the 5th–7th century AD window. Gradual multi-millennial transition would weaken the model; abrupt 6th-century transition would strongly support it.

T3 (Archaeological / geochemical): Systematic ED-E analysis of Dark-Earth profiles against predictions P1–P6 (Mildner, 2026a). Consistent failure to find the predicted signatures would substantially weaken the ED-E hypothesis.

T4 (Seismological): Permanent broadband seismometer network in the Herzberg/Doberlug area, monitoring residual micro-seismicity. Predicted: cluster at 15–25 km depth with NNW-SSE focal mechanism orientation.

T5 (Geophysical): High-resolution Bouguer gravimetric survey around the postulated Geiseltal-West impact centre. Predicted: circular −20 to −40 mGal anomaly over $r \approx 40$–50 km.

T6 (Stratigraphic): Core drilling at $\approx 52°50'$ N to establish the timing of the transition from marine/brackish to fully terrestrial sediments. Model predicts a rapid, event-driven 6th-century transition.

T7 (Cartometric): Archaeological deep drilling at *Budorigum* (Doberlug-Kirchhain), *Lugidunum* (Falkenberg/Elster), and *Stragona* (Herzberg/Elster). Roman-period occupation horizons at predicted coordinates would directly confirm the cartometric reidentification.

12. Conclusions

This paper has argued for a substantially revised interpretation of Ptolemy's *Germania Magna* that integrates cartometric analysis with geodynamics, archaeology, and historical documentation. Its central conclusions are:

1. **The primary source of discrepancy** between Ptolemaic coordinates and modern topography in Central Europe is a geologically recent, post-Ptolemaic northward shift of the *Oceanus Germanicus* coastline by ≈ 120 km. Medieval scholars projecting Ptolemy's data onto the already-transformed landscape produced all subsequent

systematic distortions.

2. **The ancient coastline position** was the endpoint of a long Holocene transgression beginning with the Littorina rise that drowned the prehistoric Blinkerwall ($\approx$ 8,500 years ago) and continuing episodically through the Bronze Age and Iron Age, progressively reducing the island of *Scandia* and generating the demographic pressures documented both by Jordanes and archaeologically by the Tollense Valley conflict.
3. **The *Vistula Fluvius*** of Ptolemy corresponds to the Lusatian river system of the Schwarze Elster, Spree, and upper Oder — an identification uniquely satisfying all topological, etymological, cartometric, and demographic constraints simultaneously.
4. **The long transgression was terminated around 525–536 AD** by a geodynamic event cluster involving cometary impacts or airbursts (documented in GISP2), regional volcanic forcing, and a late-stage reactivation of the CDF/TESZ, producing the northward regression of the coastline, the landscape catastrophe documented by the settlement hiatus, and the political collapse of the Thuringian Kingdom.
5. **Post-event tectonic settling**, documented in Gregory of Tours (563–594 AD), the Royal Frankish Annals, and the *Annales Bertiniani* (530–880 AD), constitutes an independent evidence line for the geodynamic model not previously incorporated into discussions of Ptolemaic cartography or Migration Period archaeology.
6. **The Event-Dark-Earth hypothesis** provides a falsifiable explanation for the stratigraphically anomalous Dark Earth horizon, with six specific testable predictions that distinguish event-deposit from bioturbation-reworked soil.
7. **The name *Barbarossa***, tentatively noted as a working speculation only, may preserve a distant cultural memory of a fiery, red-bearded cometary apparition — consistent with the ancient classification of the *pogonias* (bearded comet) in Pliny's *Naturalis Historia* II.22 and with the medieval *stella barbata* vocabulary — seen during the catastrophic event of 530–531 AD, subsequently transformed by oral tradition into a dynastic epithet associated with political recovery from the Migration-Period collapse.

The principal claim — that the late-Holocene landscape of Central Europe has not been as stable as conventionally assumed, and that the resulting transformation left its signature in the cartographic, sedimentary, palynological, archaeological, and historical records alike — is intended as an invitation to further interdisciplinary work. The relationship between the geological and the historical record may be more intimate, and more recent, than the prevailing assumptions of either discipline allow.

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Author's Note (Version 5, May 2026)

This version (5) revises and supersedes Version 4 of May 2026 under the same DOI. The principal substantive changes relative to Version 4 are:

- **A new sequential narrative structure** organising the argument around the three stages of: (1) long transgression from Stone Age to late antiquity; (2) crisis events of 525–536 AD terminating the transgression; (3) regression and post-antique tectonic consequences. This replaces the previous thematic structure and substantially improves logical flow and coherence.

- **The transgression–regression sequence** is now the central organising principle of the paper, making explicit that the Ptolemaic coastline position was the natural endpoint of a multi-millennial Holocene process, and that the medieval cartographic errors arose because this process was reversed catastrophically *after* Ptolemy.

- **The Blinkerwall** (Geersen et al., 2024) is integrated as the foundational evidence for the Stone Age low-sea-level baseline, providing the starting point of the transgression narrative and the demographic mechanism for *Scandia*'s reduction.

- **The Tollense Valley conflict horizon** (Jantzen et al., 2011) is integrated as the Bronze Age archaeological counterpart to the Jordanes Gothic migration narrative, linking the two through the common mechanism of population pressure on a shrinking southern Baltic island.

- **Post-antique tectonic settling** is extensively developed in a new section (Section 5.2), drawing systematically on Gregory of Tours (*Historia Francorum*: Tauredunum 563, Bordeaux 580, Tiber flood 589, earthquake cluster 590), the Royal Frankish Annals (Royal Frankish Annals, 1972) (major earthquake 801, fire from heaven 823), and the *Annales Bertiniani* (Nelson, 1991) (earthquakes 849, 863; comet 855). This evidence for prolonged post-event seismic settling has not previously been incorporated into discussions of Ptolemaic cartography or Migration Period archaeology.

- **The *Barbarossa* onomastic speculation** is substantially expanded (Section 4.4) to include the ancient vocabulary of cometary imagery. The specific classification of the *pogonias* (bearded comet) in Pliny the Elder's *Naturalis Historia* II.22.89–90 (Pliny the Elder, c. 77 AD) — and the medieval usage of *stella barbata* (bearded star) for comets in early medieval chronicles — provides the etymological and historical background for the speculative possibility that the name "Barbarossa" (red beard) preserves a distant cultural memory of the fiery, red-bearded cometary apparition of 530–531 AD, subsequently transformed by oral tradition into a dynastic epithet associated with political recovery.

- **The evidence table** (Table 1) has been extended to include the Frankish annalistic evidence (Gregory of Tours; Royal Frankish Annals; *Annales Bertiniani*) and the ecological succession evidence (Ellenberg et al. 2010; Pott 1995).
- **The quantitative proportional cross-check** of the Harz-to-Vistula-mouth distance ratio is included as a supplementary cartometric argument in an inset box.
- **All information from Version 4 is retained**; no content has been removed. The restructured text adds some additional content while substantially improving the logical architecture of the argument.

The fundamental hypothesis — that *Germania Magna* underwent a substantial, geologically recent landscape transformation whose signature is preserved in the Ptolemaic record and whose temporal sequence (transgression → crisis → regression) can be reconstructed from converging evidence across cartometry, geodynamics, archaeology, and history — is unchanged from the first version. A separate, more technical companion preprint (Mildner, 2026a) develops the cartometric residual analysis, the impact-mechanical energy budget, and the spatial correlation tests in quantitative depth.

Online resources:
`https://www.germania-magna.de` (main project site with Gazetteer and Map Overlay)
`https://www.ancientmaps-geography.com` (extended technical analyses)