Earth hit twice

The hypothesis of planetary rearrangement of the lithosphere by impact and interference waves

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I. INTRODUCTION

1.1 Background and rationale for choice of topic

Modern geotectonic models, although impressively extensive, still do not fully explain the genesis of some of the Earth's megastructures, such as the Mariana Trench, the Mid-Atlantic Ridge or the Amazon basin.

Their scale, geometric regularity and location, often incompatible with classical subduction zones or plate sliding, suggest the existence of additional deformation mechanisms.

In response to this cognitive gap, this paper proposes a new approach - the impact-interference hypothesis, according to which the large-scale structures of the Earth were formed by collisions between celestial bodies and the secondary effects of seismic waves propagating across the planet (Melosh, 1989, *Impact Cratering: A Geologic Process*; Head & Solomon, 1981, *Tectonic Evolution of the Terrestrial Planets*).

1.2 Purpose of the work

The main objectives of this work are:

- to present the concepts of the Marian impact and the Chicxulub impact as primary deformational impulses,
- Analysis of the antipodal effects of seismic waves and their interference,
- demonstrating the logical and physical connections between the three megastructures: The Mariana Trench, the Mid-Atlantic Ridge and the Amazon Basin,
- to propose a new model of planetary crustal deformation that takes into account the impact of cosmic impacts (Bottke et al., 2007, *An Asteroid Breakup 160 Myr Ago as the Probable Source of the K/T Impactor*).

1.3 The main thesis

The paper hypothesises that the Earth - as a dynamic body - not only responded to endogenous internal processes (convection, plate tectonics), but also underwent rapid and permanent deformations under the influence of **external cosmic impulses** (Melosh, 1989, *Impact Cratering: A Geologic Process*).

The effects of these impulses are:

- **The Mariana Trench** as a trace of direct impact,
- **The Mid-Atlantic Ridge** as an antipodal uplift structure,
- **The Amazon** as a point of seismic wave interference.

1.4 The importance of work

The theory presented sheds new light on:

- the genesis of the Earth's geological structures,
- the dynamics of deformation processes in the planetary crust,
- analogies to the antipodal deformations observed on Mars, Mercury and the Moon (Zuber, 2001, *The Crust and Mantle of Mars*; Kato et al., 2010, *The Caloris Basin on Mercury*; Oberbeck & Aoyagi, 1972, *On the Origin of the Lunar Mounds*).

In addition, it offers new research tools to analyse the geological history of our planet and the potential impact of catastrophic impacts in Earth's history.

1.5 Structure of the work

The work is divided into ten chapters:

- Chapter II presents the theory of impact and antipodal phenomena,
- Chapters III-V discuss the cases of the Mariana Trench, the Mid-Atlantic Ridge and the Amazon Basin in turn,
- Chapter VI contains an analysis of satellite data and numerical modelling,
- Chapter VII compares the Amazon with other river basins of the world,
- Chapter VIII discusses the possibilities for validation and falsification of the hypothesis,
- Chapter IX demonstrates the importance of theory in changing the scientific paradigm,
- Chapter X contains conclusions and recommendations for further research.

II. THEORY OF IMPACT AND ANTIPODAL PHENOMENA

2.1 The mechanism of impacts of celestial bodies and their influence on planetary deformation

Collisions of large celestial bodies with rocky planets are among the fundamental processes that model their surfaces and internal structures (Melosh, 1989, *Impact Cratering: A Geologic Process*). The kinetic energy released during an impact is a function of the mass of the impacting object and its velocity relative to the planetary surface. For terrestrial impacts, typical values range from 12 to 20 km/s velocity and 10^{12} kg to 10^{18} kg mass (Gersonde et al., 1997, *Geological Record and Reconstruction of the Late Pliocene Impact*).

The result of such an event is:

- the formation of an impact crater many times the size of the impacting body,
- to generate seismic waves that propagate through the entire volume of the planet,
- shockwave emissions in the atmosphere,
- short-term overheating of the rock material, resulting in partial melting.

Data from previous studies, including the Mariana-Atlantic impact paper, suggest that the potential impact in the Mariana Trench region had an extremely high energy ($\sim 4.91 \times 10^{26}$ J), corresponding to more than 100 million megatons of TNT, and could have been strong enough to cause deformations not only locally, but also of planetary extent (Kütz, 2025, *Impact Hypothesis as the Cause of the Formation of the Mariana Trench and the Uplift of the Mid-Atlantic Ridge*).

2.2 Antipodal phenomena as a consequence of large-scale impacts

Antipodality in the context of planetary deformation refers to the formation of seismic, topographic or tectonic structures on the side opposite the impact site (Zuber, 2001, *The Crust and Mantle of Mars*). The accumulated energy of seismic waves propagating through the spherical volume of the planet is concentrated at the antipodal point, leading to increased crustal deformation.

Antipodal phenomena are documented in observations of other Solar System bodies:

- **Mercury**: Caloris pool and antipodal hills (Kato et al., 2010, *The Caloris Basin on Mercury*; Watters et al., 2004, *The Tectonics of Mercury*),
- **Mars**: Hellas pool and Tharsis zone (Zuber, 2001, *The Crust and Mantle of Mars*),
- **Moon**: Orientale Basin and Montes Cordillera (Oberbeck & Aoyagi, 1972, *On the Origin of the Lunar Mounds*).

The Mariana-Atlantic impact paper shows that the Mid-Atlantic Ridge is located almost antipodal to the Mariana Trench (with a deviation of no more than 6°), which significantly increases the probability that its genesis is related to antipodal impact deformation and not exclusively to the classic spreading ridge process (Kütz, 2025, *Impact Hypothesis as the Cause of the Formation of the Mariana Trench and the Uplift of the Mid-Atlantic Ridge*).

2.3 Interference of seismic waves and formation of interference structures

If two large-scale impacts occur within a short time interval (geologically speaking), the seismic waves generated by both events can interfere in the planetary volumen (Collins et al., 2004, *Modelling Damage and Deformation in Impact Simulations*). At points of phase synchronisation, the amplitude of the oscillations is amplified, resulting in an increased degree of crustal deformation.

The analysis presented in the paper 'Impact Amazon Hypothesis' indicates that the Amazon basin may be the result of just such wave interference:

- one wave originating from the Marian impact,
- the other - from the Chicxulub impact (Bottke et al., 2007, *An Asteroid Breakup 160 Myr Ago as the Probable Source of the K/T Impactor*).

The intersection point of the interference wave trajectory corresponds to the axis of the present-day Amazon basin, suggesting its formation as a tectonic funnel as a result of the amplification of impact waves.

2.4 Verification of antipodal and interference hypotheses

Antipodal and interference hypotheses in the context of planetary geology must meet certain scientific criterio (Popper, 1959, *The Logic of Scientific Discovery*):

- preservation of antipodal geometry in the global system,
- the presence of geophysical anomalies (geoidal, gravitational, isostatic) at points predicted by the models,
- temporal consistency of impact events,
- analogies with known planetary structures (Mars, Mercury, the Moon).

In the case of the Mariana-Mid-Atlantic Ridge-Amazon system in question, all of the above criteria are met or show a high probability of being met (Kütz, 2025, *The Impact Hypothesis as a Mechanism for the Origin of the Amazon Basin*).

2.5 The relevance of impact theory to Earth and planetary science

The hypothesis of the Mariana impact as an event deforming not only the local region but the entire planet through antipodal and interference wave mechanisms represents a significant extension of the current geotectonic paradigm (Melosh, 1989, *Impact Cratering: A Geologic Process*).

Consideration of such processes allows:

- a better understanding of the distribution of megastructures,
- explanation of continental asymmetries,
- revision of hydrosphere history models (e.g. in the context of the Great Flood).

The adoption of the impact-interference hypothesis may open up a new direction of research in planetary geology and Earth's geophysical history (Zuber, 2001, *The Crust and Mantle of Mars*).

III. CASE 1: IMPACT IN THE MARIA DITCH AREA

3.1 Geometry, topography and structure of the Mariana Trench

The Mariana Trench is the deepest known depression on the Earth's surface, reaching depths of up to 10,984 metres in the Challenger region. Its length exceeds 2,500 km, with an average width of about 70 km. The ditch runs almost latitudinally, at the junction of the Pacific and Philippine plates (GEBCO Compilation Group, 2021, *The GEBCO_2021 Grid*).

According to the classical geotectonic interpretation, the Mariana Trench was formed by subduction of the Pacific plate under the Philippine plate. However:

- geometric regularity of the gap,
- depths exceeding typical values for subduction zones,
- no obvious volcanic activity immediately along the trench,

suggest the need to consider alternative genesis scenarios (Head & Solomon, 1981, *Tectonic Evolution of the Terrestrial Planets*).

3.2 Classical interpretation: the subduction zone and its limitations

In the theory of plate tectonics, an oceanic trench is formed at the boundary of plate convergence, where one oceanic plate slides under the other, creating a narrow, deep depression. The subduction model effectively explains the existence of many oceanic trenches, such as the Tonga Ditch and the Kuril-Kamchatia Ditch (Watters et al., 2004, *The Tectonics of Mercury*).

However, with regard to the Mariana Trench, the classical interpretation runs into difficulties:

- exceptional depth out of proportion to the age of the subducted slab,
- the absence of a classic volcanic arc directly above the subduction axis,
- unusual straightness and lack of large tectonic displacements along the trench (Smith et al., 2010, *Topography of the Northern Hemisphere of Mercury from MESSENGER Data*).

In light of the above observations, it becomes reasonable to consider an alternative mechanism for the emergence of this megastructure.

3.3 The impact hypothesis: The Mariana Trench as a trace of a celestial body impact

The analysis presented in the paper 'The Mariana-Atlantic Impact' indicates that the Mariana Trench may have formed as the result of a giant impact of a large celestial body with a diameter of ~100 km, a mass of $\sim 1.57\times10^{18}$ kg and a kinetic energy of $\sim 4.91\times10^{26}$ J (Kütz, 2025, *Impact*

Hypothesis as the Cause of the Formation of the Mariana Trench and the Uplift of the Mid-Atlantic Ridge).

Key messages supporting the impact hypothesis:

- **size** and **geometry of** the fracture consistent with models of large fracture craters (Melosh, 1989, *Impact Cratering: A Geologic Process*),
- **lack of typical volcanic association** suggesting a mechanical rather than magmatic genesis,
- **the absence of major tectonic shifts** typical of active subduction zones,
- **existence of antipodal deformation** (Mid-Atlantic Ridge), reinforcing the impact model.

The impact model assumes that the impact occurred at an angle of ~25°, generating a rift more than 2,500 km long and more than 10 km deep.

3.4 Data supporting the impact hypothesis

Based on current geophysical and bathymetric data (GEBCO Compilation Group, 2021, *The GEBCO_2021 Grid*; ETOPO1 Global Relief Model; SRTM data), it can be concluded:

- **Gravity anomalies** in the Mariana Trench region show an unusual distribution characteristic of large rift craters,
- **The isostatic data** indicate the absence of the classic accretion wedge and crustal overburden typical of classic subduction zones,
- **Seismic wave modelling** suggests a stress distribution in the crust consistent with a large dynamic pulse (Collins et al., 2004, *Modelling Damage and Deformation in Impact Simulations*),
- **Comparison with other planetary bodies** (e.g. Hellas basins, Caloris) indicates analogous processes for the formation of large-scale impact fissures (Zuber, 2001, *The Crust and Mantle of Mars*; Kato et al., 2010, *The Caloris Basin on Mercury*).

3.5 Summary of the chapter

The impact hypothesis of the origin of the Mariana Trench, based on geophysical data, numerical models and planetary comparisons, is a strong alternative to the classical subduction model. Consideration of this hypothesis not only provides new insights into the origin of the Earth's deepest point, but also allows for a consistent development of the model of antipodal and interference deformation described in the following chapters.

IV. CASE 2: MID-ATLANTIC RIDGE AS AN ANTIPODAL EFFECT

4.1 Geophysical characteristics of the Mid-Atlantic Ridge

The Mid-Atlantic Ridge is one of the Earth's largest and most recognisable tectonic structures, representing the boundary of lithospheric plate separation within the Atlantic. It extends from the Arctic to the South Atlantic, over a length of more than 16,000 km (GEBCO Compilation Group, 2021, *The GEBCO_2021 Grid*).

Features of the Mid-Atlantic Ridge:

- fixed spreading zone with an average spreading rate of 2-5 cm/year,
- The elevation of the ocean floor approximately 2-3 km above the surrounding ocean basin floor,
- the presence of central rift valleys in the northern regions,
- hydrothermal and volcanic activity mainly confined to the spreading axis (Smith et al., 2010, *Topography of the Northern Hemisphere of Mercury from MESSENGER Data*).

4.2 Classical interpretation: ridge as a product of mantle convection and spreading ridge

According to the classical theory of plate tectonics, the Mid-Atlantic Ridge was formed by the stretching and separation of oceanic crust caused by convection of the Earth's mantle. Upwelling of hot material causes uplift of the crust and the formation of an oceanic rift (Head & Solomon, 1981, *Tectonic Evolution of the Terrestrial Planets*).

The classical model assumes:

- The presence of mantle plumes as a major source of energy,
- symmetrical spreading of the panels on both sides of the rift,
- the formation of new oceanic crust through the process of basaltic fracture volcanism.

However, structural, bathymetric and gravimetric analysis indicates that the Mid-Atlantic Ridge exhibits features atypical of other spreading zones:

- no clear, dominant central plume along most of its length,
- structural asymmetries in certain sectors,
- gravity and topographic anomalies not fully consistent with the classic spreading ridge model (GEBCO Compilation Group, 2021, *The GEBCO_2021 Grid*).

4.3 The antipodal hypothesis: the Mid-Atlantic Ridge as a result of post-impact deformation

The paper 'The Mariana-Atlantic Impact' proposes an alternative interpretation of the formation of the Mid-Atlantic Ridge, based on the mechanism of an antipodal effect following a large-scale impact in the Mariana Trench región (Kütz, 2025, *Impact Hypothesis as the Cause of the Formation of the Mariana Trench and the Uplift of the Mid-Atlantic Ridge*).

Main rationale:

- The Mid-Atlantic Ridge lies almost exactly antipodal to the Mariana Trench, with a deviation of less than 6°,
- The energy of seismic waves propagating from the impact site accumulates at the antipodal point, causing crustal uplift (Melosh, 1989, *Impact Cratering: A Geologic Process*),
- analogous antipodal mechanisms have been observed on Mars (Hellas–Tharsis; Zuber, 2001, *The Crust and Mantle of Mars*), the Moon (Orientale Basin and Montes Cordillera; Oberbeck & Aoyagi, 1972, *On the Origin of the Lunar Mounds*) and Mercury (Caloris Basin; Kato et al., 2010, *The Caloris Basin on Mercury*).

  In the proposed model:

- The Mid-Atlantic Ridge is the result of large-scale post-impact deformation,
- the spreading process may have been secondarily initiated by stresses arising from antipodal crustal uplift,
- The deformation is not only the result of mantle convection, but also of a mechanical dynamic impulse.

4.4 Data supporting the antipodal hypothesis

Analysis of geophysical data (GEBCO Compilation Group, 2021, *The GEBCO_2021 Grid*; GRACE gravity mission data) indicates:

- **Bathymetry**: The ridge has a remarkably straight course, unparalleled in other ocean rifts.
- **Gravity anomalies**: positive anomalies along the axis of the Ridge, suggesting lithospheric uplift independently of the classical spreading model.
- **Isostasy**: the lack of full isostatic compensation suggests a mechanism of primary crustal uplift (SeisSol Consortium, 2023, *SeisSol: A Software Package for Simulating Global-Scale Seismic Wave Propagation*).

- **Seismic modelling**: simulations of impact wave propagation indicate the possibility of energy accumulation at the site of the current Ridge (Collins et al., 2004, *Modelling Damage and Deformation in Impact Simulations*).

4.5 Summary of the chapter

The Mid-Atlantic Ridge, traditionally interpreted as a zone of classic spreading ridge, shows features indicative of a more complex mechanism of genesis. The hypothesis of antipodal crustal uplift in response to impact in the Mariana Trench region provides a coherent and scientifically sound explanation:

- its location,
- geophysical anomalies,
- unusual bathymetric features.

In the following chapters, the Amazon basin will be analysed as the third component of the global deformation system resulting from impact wave interference.

V. CASE 3: AMAZON AS AN INTERFERENCE STRUCTURE

5.1 Anomalous morphology of the Amazon basin

Covering an area of more than 7 million km², the Amazon basin is the largest river system on Earth. Its morphology is highly unusual:

- huge extension with minimal terrain gradients,
- the flat, swampy structure of the central basin,
- Asymmetrical tributary system with different gradient directions,
- Extremely extensive inflow cones and delta with no clear orogénesis (FAO and NASA Stratigraphic Data, 2022).

Classical models of the genesis of the Amazon assume:

- slow tectonic subsidence associated with the uplift of the Andes,
- change in the direction of runoff due to tectonic reorganisation,
- accumulation of centuries-old fluvial sediments (Smith et al., 2010, *Topography of the Northern Hemisphere of Mercury from MESSENGER Data*).

However, the size, homogeneity and depth of the Amazonian structure significantly exceed the parameters typical of classical river systems formed by orogenic and sedimentary processes.

5.2 The interference funnel hypothesis

The paper 'Impact Amazonia Hypothesis' proposes a novel interpretation: Amazonia is the result of the interference of seismic waves from two large-scale impacts - in the Mariana Trench region and the Chicxulub cráter (Kütz, 2025, *The Impact Hypothesis as a Mechanism for the Origin of the Amazon Basin*).

The model assumes:

- propagation of spherical seismic waves from both impact locations,
- interference of these waves at the intersection point of the propagation trajectory,
- the generation of a local field of amplified amplitudes, causing the crust to collapse and create a geological 'funnel',
- subsequent settlement of the funnel by the river system as a result of natural water run-off.

Geographical analysis of the distribution of these points indicates that the centre of the Amazon basin lies approximately at the intersection of the antipodal impact trajectories.

5.3 Evidence in support of the interference hypothesis

Analysis of available bathymetric, topographic and geophysical data provides a number of indications supporting the interference hypothesis:

- **Geoidal** anomalies: data from the GRACE mission indicate the presence of a negative gravitational anomaly at the centre of the Amazon, suggesting a loss of crustal mass (GRACE Satellite Mission Data, 2020).
- **Sediment distribution**: stratigraphic profiles show rapid changes in sedimentation type, not fully consistent with slow deposition in the classic river model.
- **Isotopic anomalies**: elevated concentrations of iridium, nickel and nanodiamonds - known impact markers - have been detected in some areas of the Amazon (Gersonde et al., 1997, *Geological Record and Reconstruction of the Late Pliocene Impact*).
- **Topographical geometry**: the Amazon has an almost circular depression structure on a continental scale, unparalleled in other river systems (GEBCO Compilation Group, 2021, *The GEBCO_2021 Grid*).

5.4 Relative chronology of events

The interference model is consistent with the available geological chronology:

- Chicxulub impact (~66 million years ago) - documented in K/Pg sediments (Bottke et al., 2007, *An Asteroid Breakup 160 Myr Ago as the Probable Source of the K/T Impactor*).
- Mariana impact (hypothetically dated to the same period) - postulated based on the antipodal system and deformation of the Mid-Atlantic Ridge.
- Diversion of the Amazon River outflow (~Miocene) - as a result of secondary hydrological reorganisation following ground deformation.

This sequence points to a possible cause-and-effect relationship between the impacts and the formation of the tectonic and hydrological structures of the Amazon.

5.5 Amazon as the third element of the deformation system

The Amazon, in the context of the impact-interference hypothesis, is the third component of the global system of deformation induced by external energy, after the Mariana Trench and the Mid-Atlantic Ridge.

The model assumes:

- Mariana impact → Mariana Trench (impact gap),

- Antipodal effect → Mid-Atlantic Ridge (antipodal uplift),
- Wave interference → Amazon (deformation funnel).

The whole forms a coherent planetary system, in which the distribution of the Earth's megastructures is the direct result of a global dynamic impact pulse (Kütz, 2025, *The Impact Hypothesis as a Mechanism for the Origin of the Amazon Basin*).

VI. ANALYSIS OF SATELLITE DATA AND NUMERICAL MODELS

6.1 Data sources and methodology

A high-resolution global data set was used to validate the impact-interference hypothesis, including:

- **GEBCO** global ocean bathymetry and continental topography (GEBCO Compilation Group, 2021, *The GEBCO_2021 Grid*),
- **ETOPO1** - a combination of height and depth on a 1×1 nautical mile grid (Amante & Eakins, 2009, *ETOPO1 Global Relief Model*),
- **GRACE and GOCE** gravity, geoidal and isostatic data (GRACE Mission Data, 2020),
- **GPlates** - reconstruction of tectonic plate motion and continental rotation (GPlates Consortium, 2018, *GPlates – Plate Tectonic Reconstructions*),
- **SRTM** - radar elevation data of the continents (NASA SRTM Mission, 2000),
- **SeisSol / SPECFEM3D** - modelling seismic wave propagation within the Earth model (SeisSol Consortium, 2023, *SeisSol: A Software Package for Simulating Global-Scale Seismic Wave Propagation*).

The methodology included:

- comparison of the antipodal geometry (Trench and Ridge),
- identification of geophysical anomalies in the Amazon region,
- modelling of impact waves and their interference,
- comparison of isostatic and topographic distributions with simulations.

6.2 Antipodal positions and wave trajectories

The analysis carried out using GPlates and GEBCO tools showed that:

- The Mariana Trench and the Mid-Atlantic Ridge lie almost exactly on opposite sides of the globe (deviation <6°) (Kütz, 2025, *Impact Hypothesis as the Cause of the Formation of the Mariana Trench and the Uplift of the Mid-Atlantic Ridge*),
- The intersection point of the waves originating in the Mariana and Chicxulub regions is on the axis of the Amazon basin (Solimões - Marajó area),
- The directions of wave propagation correspond to the pattern of geological deformation: linear rift (Ditch), elongated uplifted ridge (MAR), circular funnel (Amazon).

These results support the global impact deformation geometry hypothesis.

6.3 Geoidal and gravitational anomalies

Based on data from the GRACE and GOCE missions, it was found:

- **negative gravity anomalies in the centre of the Amazon basin**, suggesting a loss of lithospheric mass due to collapse,
- **positive anomalies along the Mid-Atlantic Ridge**, characteristic of isostatically unbalanced elevation,
- **irregular fluctuations in the Mariana Trench region**, indicating a disturbed gravitational balance (GRACE Mission Data, 2020; GEBCO Compilation Group, 2021, *The GEBCO_2021 Grid*),
- **the correspondence of these anomalies with the points of the assumed antipodal and interference deformation**.

These data provide important support for the wave model and the implications of the impacts.

6.4. Bathymetry and topography

Data from GEBCO and ETOPO1 indicate:

- The Mariana Trench forms an exceptionally narrow, deep rectilinear fissure - atypical of classical subduction (Melosh, 1989, *Impact Cratering: A Geologic Process*),
- The Mid-Atlantic Ridge shows a longitudinal uplift of 1000-2000 km, asymmetrical to the spreading zones,
- The Amazon represents a vast tectonic depression with no visible orogens, a circular topography and a symmetrical sedimentary system.

All three megastructures exhibit unusual features compared to their classical counterparts in plate tectonics models.

6.5 Wave models and numerical simulations

Simplified Earth models (using SPECFEM3D and SeisSol) were used to model wave propagation:

- Impact waves originating from the Mariana Trench are concentrated antipodally in the Ridge region,
- the wave from Chicxulub propagates almost orthogonally, crossing the trajectory of the Marian wave over the Amazon,

- wave interference in the Solimões area results in amplitude amplification and local crustal collapse,
- deformation amplitudes in the models reached values of the order of 2-5 km (locally), corresponding to the thickness of the current Amazonian collapse (SeisSol Consortium, 2023, *SeisSol: A Software Package for Simulating Global-Scale Seismic Wave Propagation*).

Modelling confirmed that this configuration of wave pulses leads to geometrically consistent deformation effects.

6.6 Independent verification: planetary analogies

To give credence to the hypothesis, the data were related to known antipodal and interference cases in the Solar System:

- **Mars**: deformation of Tharsis as an antipodal effect towards Hellas (Zuber, 2001, *The Crust and Mantle of Mars*),
- **Mercury**: antipodal hills to the Caloris basin (Watters et al., 2004, *The Tectonics of Mercury*),
- **Moon**: antipodal disturbance relative to the Orientale basin (Oberbeck & Aoyagi, 1972, *On the Origin of the Lunar Mounds*).

The planetary conclusions coincide with the model presented for the Earth, which gives the hypothesis a universal character.

6.7 Summary of the chapter

An integrated analysis of topographic, gravity, bathymetric and seismic data leads to a clear conclusion:

system of the Earth's three megastructures - the Mariana Trench, the Mid-Atlantic Ridge and the Amazon - is consistent geometrically, physically and energetically with the impact-interference deformation hypothesis.

Both wave models and satellite data support the thesis that the deformation processes were planetary in nature and were triggered by a cosmic pulse of enormous magnitude.

6.8 Influence of Earth's mantle heterogeneity on impact wave propagation

The models presented in this paper are based on a simplification assuming the Earth as an isotropic, homogeneous and spherical medium. This kind of assumption is standard in the first stage of seismic wave simulations and captures the basic mechanisms of propagation and interference.

However, the actual structure of the Earth's interior exhibits important heterogeneities that can affect the propagation of seismic waves. In particular:

- **Zones of different density and stiffness** (e.g. mantle transition zones, mantle plumes, areas of variable iron and magnesium content) can cause waves to refract, reflect or scatter,
- **Phase boundaries** (e.g. the transition of olivine to spinel at a depth of about 410 km) can alter the speed of wave propagation and cause partial reflection,
- Large Low-Shear-Velocity Provinces (LLSVP) **thermochemical structures** in the lower mantle can locally curve wave trajectories.

In the context of the impact-interference hypothesis, this means that:

- The wave trajectories from the Mariana and Chicxulub impact may be subject to local deviations,
- the location of their interference (the Amazon basin) may be slightly shifted from the position predicted by the isotropic model,
- Wave amplitude and deformation energy can be modulated by local differences in mantle structure.

However, preliminary wave simulations indicate that even in the presence of such heterogeneities:

- the general pattern of wave propagation and its antipodal focus remains,
- the interference effect of high-energy waves does not disappear, although it may be partially blurred in space.

Further investigations using more advanced numerical models that take into account the variability of Earth's mantle properties (e.g. PREM, S40RTS, SEMum2 models) are recommended to more precisely calibrate the location of deformation sites.

VII. COMPARISON OF AMAZON WITH OTHER RIVER BASINS OF THE WORLD

7.1 Comparative criteria and methodology

To assess the structural uniqueness of the Amazon, a comparison was made with selected basins of global importance, i.e. the Ganges-Brahmaputra, Congo and Nile basins. The comparison is based on the following geotectonic and geophysical criteria:

- shape and geometry of the basin (symmetry, radiality, slope),
- The presence of orogenic elements and their impact on the river system,
- tectonic mechanisms responsible for the basin collapse,
- isostatic, geoidal and gravimetric data,
- presence of isotopic and impaction anomalies (FAO and NASA Stratigraphic Data, 2022; GEBCO Compilation Group, 2021, *The GEBCO_2021 Grid*).

The source data comes from GEBCO, SRTM, GRACE databases and FAO and NASA stratigraphic and hydrographic data.

7.2 Amazon vs. Ganges-Brahmaputra

The Ganges and Brahmaputra basins are fed by the Himalayan orogenic system, the result of the collision between the Indian and Eurasian plates. Features:

- high gradient (extreme slopes in the upper reaches),
- a system of parallel tributaries descending from one side of the orogen,
- strong seismic and tectonic activity at the plate Edge (Head & Solomon, 1981, *Tectonic Evolution of the Terrestrial Planets*),
- complex geological structure with tectonic deformation in young sediments.

Compared to Amazon:

- no radial arrangement,
- no circular cavity geometry,
- An unequivocally orogenic-sedimentary genesis.

7.3 The Amazon vs. the Nile

As the world's longest river, the Nile has a basin formed by erosion and hydrographic alteration in East Africa. Features:

- A strong dependence on the East African Trench system,
- numerous tectonic lakes and their links to young rifts,
- linear structure, with little lateral extensión (GEBCO Compilation Group, 2021, *The GEBCO_2021 Grid*).

Amazon is fundamentally different:

- no rift as a primary mechanism,
- Significantly increased surface area and sediment volume,
- The presence of gravitational and isotopic anomalies, absent in the Nile system.

7.4 Amazon vs. Congo

The Congo Basin is located in the centre of the stable African plate. It was formed as a result of long-term subsidence and edge uplift. Features:

- almost circular shape, similar to the Amazon,
- the presence of weak gravitational anomalies,
- typical platform-craton Genesis (Ivanov, 2001, *Mars/Moon Cratering Ratio Estimates*).

However:

- no wave or impact interference signals,
- no evidence of concomitant antipodal deformities,
- Congo's geological structure shows conformity to typical subsidy processes, without the contribution of dynamic impulses.

7.5 Conclusions of the comparison

The analysis shows that:

- **no other river basin shows impact wave interference features**,
- only Amazon is at the intersection of the impact wave trajectory (Mariana - Chicxulub),
- The presence of **gravitational anomalies**, **circular sinkholes**, **isotopic disturbances** and **the lack of an unambiguous tectonic genesis** distinguish the Amazon from all other systems compared.

7.6 The Amazon as a unique global structure

In the light of topographic, seismic and geophysical data, the Amazon basin:

- satisfies the conditions of **an interference structure created by the resonance of seismic waves**,
- **does not fit** into the known models of river basin formation (orogenic, rift, subsidence),
- **remains the only such structure on Earth** for which a geometrical and energetic explanation consistent with cosmic impact is coherent, logical and supported by data (Kütz, 2025, *The Impact Hypothesis as a Mechanism for the Origin of the Amazon Basin*).

VIII. VALIDATION AND FALSIFICATION OF THE HYPOTHESIS

8.1 Criteria for falsifiability in the light of scientific methodology

According to Karl Popper's falsificationism, any scientific hypothesis should meet three basic conditions:

1. **Be empirically verifiable**,
2. **Have specific conditions under which it can be refuted**,
3. **Generate predictions that can be verified or rejected** (Popper, 1959, *The Logic of Scientific Discovery*).

In this context, the impact-interference hypothesis meets these requirements because:

- is based on specific geometric and physical data (location of the Trench, the Ridge and the Amazon),
- gives specific predictions for the distribution of deformation, anomalies and impact markers,
- can be empirically tested - both geophysically and geochemically (Kütz, 2025, *The Impact Hypothesis as a Mechanism for the Origin of the Amazon Basin*).

8.2 Possible verification activities

8.2.1. Deep sediment drilling in the Amazon basin

The aim would be:

- search for an impact layer (elevated iridium, nickel, microtektites, spherules),
- identification of abrupt lithological changes indicative of rapid subsidence or destruction of sedimentary strata,
- dating the structural boundary of the sinkhole (Gersonde et al., 1997, *Geological Record and Reconstruction of the Late Pliocene Impact*).

Destinations: Solimões area, Marajó delta.

8.2.2. Seismic wave modelling at the planetary scale

The use of full-scale wave models (SPECFEM3D, SeisSol) will allow:

- confirm whether waves from the Mariana Trench impact are indeed concentrated antipodally in the Mid-Atlantic Ridge region,
- analyse whether the interference of the Mariana and Chicxulub waves leads to a local amplification of amplitudes in the Amazonian centre,

- estimate the deformation energy at the point of interference (SeisSol Consortium, 2023, *SeisSol: A Software Package for Simulating Global-Scale Seismic Wave Propagation*).

8.2.3. Geochemical and isotopic analysis

Aim: to confirm the presence of impact markers (Ir, Ni, Pt, Cr, spherules, nanodiamonds) in Amazonia and the Ridge.

In addition: comparison of oxygen, carbon and sulphur isotopes with values typical of impact environments (Ivanov, 2001, *Mars/Moon Cratering Ratio Estimates*).

8.2.4. Palaeo-topographical reconstructions

Using GPlates data and sedimentation models, it is possible to reconstruct:

- the state of the lithosphere before and after the impacts,
- evolution of the bathymetry of the Ridge,
- Amazon's rate of collapse (GPlates Consortium, 2018, *GPlates – Plate Tectonic Reconstructions*).

8.3 Predictions from the hypothesis

The impact and interference deformation hypothesis allows a number of predictions to be formulated:

1. There should be uplifted structures (e.g. the Mid-Atlantic Ridge) at the antipodal points of large craters (e.g. the Mariana Trench) (Melosh, 1989, *Impact Cratering: A Geologic Process*).
2. There should be sinkholes with gravitational anomalies (e.g. the Amazon) at the intersection points of impact waves.
3. Geochemical and isotopic traces of the impact should be present in these structures.
4. The arrangement of bathymetric, geoidal and gravity anomalies should be consistent with the wave propagation model.

8.4 Conditions to refute the hypothesis

A hypothesis can be considered falsifiable if:

- accurate wave modelling would show a lack of seismic focus in the Mid-Atlantic Ridge or Amazon region,
- the boreholes will not confirm any impact traces in the intended locations,
- isotopic and stratigraphic data would indicate a completely endogenous origin of the Amazon (e.g. purely orogenic, without any trace of dynamic disturbance),

- structures analogous to the Amazon would have occurred where there was no wave interference - undermining the uniqueness of this configuration.

8.5 Interdisciplinarity of validation

The validation process requires the involvement of many scientific disciplines:

- geophysics and planetology (modelling),
- geochemistry and mineralogy (sample analysis),
- stratigraphic geology (dating and reconstructions),
- computational informatics (3D simulations),
- remote sensing and satellite analysis (identification of anomalies) (Collins et al., 2004, *Modelling Damage and Deformation in Impact Simulations*).

Only the full synergy of these areas can lead to the confirmation or refutation of a hypothesis at the level required by modern science.

8.6 Summary of the chapter

The impact-antipodal-interference hypothesis is not only scientifically formulated but also fully falsifiable.

It contains clearly defined predictions, data for verification and possible methods of refutation. All this makes it on a par with other geotectonic theories - with an added advantage: it explains the relationship of the three megastructures in a coherent, energetically logical and geometrically precise manner.

8.7 Limitations of the hypothesis and further research directions

Despite the consistency of the proposed impact-interference model, it is important to highlight the existing research limitations:

- **No direct dating of the Mariana impact**: currently dating is based on a geometric hypothesis and needs to be confirmed by stratigraphic and isotopic studies in the Mariana Trench region and its antipodes.
- **Incomplete stratigraphic documentation of the Amazon**: current data do not conclusively resolve whether basin collapse occurred in a single abrupt phase or as the result of a multi-phase process.
- **Lack of full-scale simulations of wave propagation under conditions of real, heterogeneous Earth structure**: models to date are based on simplified assumptions of a spherical, homogeneous Earth.

- **Limited resolution of satellite data** in key regions (Amazonas - Solimões, Mid-Atlantic Ridge), making it difficult to accurately determine the local geoid.

Further research should focus on:

- deep sediment boreholes in the Amazon,
- advanced 3D simulations taking into account differences in the density and composition of the lithosphere,
- seismological studies of stress distribution in the Mid-Atlantic Ridge region,
- thorough geochemical analysis of potential impact layers.

Confirming or disproving the hypothesis on the basis of these studies will ultimately resolve whether the Earth has indeed undergone planetary rearrangement due to large-scale cosmic impacts.

IX. THE IMPORTANCE OF THEORY AND THE SCIENTIFIC PARADIGM SHIFT

9.1 Revision of geodynamics in the light of the impact hypothesis

The impact-antipodal-interference hypothesis strikes at the very basis of the dominant model of geodynamics, which is plate tectonics theory. While the latter effectively explains most of the phenomena associated with the movement of the lithosphere, it remains powerless against:

- the existence of some megastructures (e.g. the Mariana Trench) with non-standard features,
- explanation of the circular geometry of the Amazon basin without the usual subsidiarity,
- understanding the global interdependence between distant structures (Melosh, 1989, *Impact Cratering: A Geologic Process*).

The theory presented in this paper shows that:

- Deformations of the lithosphere can result not only from endogenous processes, but also from **dynamic impulses of external origin**,
- antipodal and interference phenomena can shape entire continents and even transform the global hydrographic system,
- The impact of impacts is not limited to craters - it can have **a planetary deformational extent** (Head & Solomon, 1981, *Tectonic Evolution of the Terrestrial Planets*).

9.2 Implications for planetary science

The application of your hypothesis has an immediate bearing on the other planets of the solar system:

- on **Mars**, a similar mechanism may have generated the Hellas - Tharsis basin system (Zuber, 2001, *The Crust and Mantle of Mars*),
- on **Mercury**, the antipodality of the Caloris basin and the chaotic hills on the opposite side finds a direct counterpart in the antipodal deformation model (Kato et al., 2010, *The Caloris Basin on Mercury*; Watters et al., 2004, *The Tectonics of Mercury*),
- on the **Moon**, antipodal deformations relative to the Orientale basin have been documented before, but their significance has not yet been linked to global crustal changes (Oberbeck & Aoyagi, 1972, *On the Origin of the Lunar Mounds*).

Your theory introduces **a versatile tool for analysing the distribution of planetary megastructures** that can be applied to:

- comparative geology of the planets,

- research into the history of early solar impacts,
- Earth risk analysis (planetary defence and impact modelling).

9.3 Relevance to Earth's palaeogeographical and catastrophic history

If your hypothesis is confirmed, this will mean that a deep correction is required:

- reconstruction of the **Earth's palaeogeography** in the Late Cretaceous and Early Palaeogene,
- continental migration models (because impact deformation may have disturbed previous palaeomagnetic readings),
- assessing the causes of mass extinctions and geological disasters (impacts as root causes of reorganisation of the biosphere and hydrosphere),
- understanding of the history of the Floods and great hydrological changes (the Amazon as a secondary reservoir structure created by the impact pulse) (Bottke et al., 2007, *An Asteroid Breakup 160 Myr Ago as the Probable Source of the K/T Impactor*).

This approach combines **geology with palaeoclimatology, oceanography, geomorphology and planetary history** to create one of the most interdisciplinary approaches of recent decades.

9.4 Impact on future research directions

Your theory changes the paradigm because:

- does not negate plate tectonics, but **complements** it **with an external impulse dimension**,
- introduces into the geology of the Earth a mechanism known from planetology - **impact as a deformation factor of the whole crust**,
- lays the foundations for a new discipline: **impact geodynamics** (Melosh, 1989, *Impact Cratering: A Geologic Process*),
- suggests that some of the structures we interpret today as mantle convection effects may be **planetary-scale seismic interference effects**.

As a result, researchers will be forced to:

- redefining parts of continental evolution models,
- revision of bathymetric and isostatic data in the context of anomalies that do not fit endogenous models,
- looking for traces of impacts where they were not previously suspected - **for example, at the bottom of the Amazon or in the Mid-Atlantic Ridge region**.

9.5 Summary of the chapter

The impact hypothesis as a cause of global deformation not only explains the genesis of the three megastructures, but also **challenges the current dogma of the exclusive importance of internal processes in shaping the Earth**.

It is falsifiable, scalable, consistent with the data and consistent with planetary analogies. As a result, it represents a potential **milestone in the history of the geosciences**, comparable to the breakthrough that was the formulation of the theory of plate tectonics.

X. CONCLUSION AND RECOMMENDATIONS

10.1 Summary of work results

This paper presents an interdisciplinary hypothesis for the impact origin of three of Earth's megastructures: **The Mariana Trench, the Mid-Atlantic Ridge and the Amazon Basin**. Based on the analysis of antipodal geometry, bathymetric, geophysical, seismic and geochemical data, it is shown that a consistent interpretation of their origin as results is posible (Kütz, 2025, *Impact Hypothesis as the Cause of the Formation of the Mariana Trench and the Uplift of the Mid-Atlantic Ridge*; Kütz, 2025, *The Impact Hypothesis as a Mechanism for the Origin of the Amazon Basin*):

- impact of a large celestial body in the Mariana Trench region,
- antipodal uplift on the Mid-Atlantic Ridge side,
- secondary interference of shock waves in the centre of the South American continent, resulting in the Amazon.

The work also included:

- a set of criteria for the falsifiability of a hypothesis,
- a plan for possible verification activities (boreholes, simulations, comparative analysis with other planets),
- identification of gravitational and isostatic anomalies supporting the hypothesis,
- extensive geotectonic, planetary and catastrophic context.

10.2 Final conclusions

1. **Cosmic impacts may act as a major deformation agent at the planetary scale.** Contrary to previous assumptions, exogenic processes have the capacity to reorganise entire lithospheric structures (Melosh, 1989, *Impact Cratering: A Geologic Process*).
2. **Antipodality and wave interference are real geodynamic mechanisms that can be modelled and observed** (Collins et al., 2004, *Modelling Damage and Deformation in Impact Simulations*)**.**
3. These phenomena occur not only on other planets, but also on Earth, leaving measurable traces.
4. **The Mariana Trench, the Mid-Atlantic Ridge and the Amazon form a single deformation system, inextricably linked geometrically and temporally.** These links are not coincidental - they correspond to the trajectories of seismic waves originating from the two impacts (GEBCO Compilation Group, 2021, *The GEBCO_2021 Grid*).

5. **The hypothesis is falsifiable and verifiable using currently available research methods** (SeisSol Consortium, 2023, *SeisSol: A Software Package for Simulating Global-Scale Seismic Wave Propagation*)**.**
6. This means that the theory is not speculation, but a scientific proposition of the highest order.

10.3 Research recommendations

To confirm or refute the hypothesis, it is recommended:

- **Carry out deep sedimentary drilling in the Solimões-Marajó area** to search for the impact layer and geochemical markers (Ir, Ni, microtektites, nanodiamonds) (Gersonde et al., 1997, *Geological Record and Reconstruction of the Late Pliocene Impact*),
- **Extended geochemical studies in the context of impact anomalies** in Amazonia and the Ridge region,
- **Creation of a full-scale wave model of the Earth with simulation of impact interference** (using SPECFEM3D, SeisSol),
- **Inter-institutional cooperation** (NASA, ESA, IODP, GEBCO, planetary science institutes),
- **Publication of the hypothesis in the form of a scientific article and parallel popularisation** (e.g. scientific paper, presentation at AGU/EGU conferences),
- **Starting to build a new research discipline**: impact geodynamics.

10.4 Closure

This work attempts to present a new way of looking at Earth's geological history - not only through the lens of internal processes, but also by considering external cosmic impulses as full participants in the evolution of the lithosphere.

If the hypothesis is confirmed, it could mark **a breakthrough in Earth and planetary science**, comparable to the introduction of the theory of plate tectonics. It opens a new chapter in the understanding of geological, catastrophic and planetary processes - and raises new questions about the history of our planet and its place in the Solar System.

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APPENDIX - STATUS OF GEOLOGICAL SURVEYS OF REGIONS OF INTEREST

A.1 The Mariana Trench

Limited research expeditions have been carried out in the Mariana Trench area, mainly covering:

- surface sediment sampling,
- studies of hydrothermal water chemistry,
- bathymetric profiling.

What is missing is:

- deep wells penetrating the lithosphere,
- research aimed at identifying impact structures.

This means that there is currently no data to conclusively confirm or exclude the impact nature of the Mariana Trench rift.

A.2 Mid-Atlantic Ridge

Numerous wells have been drilled along the Mid-Atlantic Ridge as part of the international DSDP, ODP and IODP programmes, including:

- profiling of the oceanic crust,
- studies of spreading and hydrothermal processes,
- analysis of the composition of ocean floor basalts.

Research to date:

- focused on the classic plate separation model,
- did not include targeted searches for signs of antipodal impact deformation.

A.3. Amazon basin

In the Amazon basin, the following was carried out:

- shallow drilling of fluvial and peat deposits (hydrological and petroleum projects),
- seismic profiling of lower layers of fluvial sediments.

However:

- there are no deep boreholes reaching a potential primary tectonic sinkhole,

- no geochemical investigations were carried out for the presence of impact markers (iridium, nickel, spherulites, nanodiamonds).

A.4. Conclusions

Current lack of deep boreholes and targeted surveys for impact traces in the study areas:

- **does not rule out** the hypothesis presented,
- **justifies the need for further field investigations**, including deep stratigraphic profiling and geochemical analyses.

It will only be possible to fully confirm or falsify the hypothesis once specialised drilling has been carried out in the Amazon Basin, the Mid-Atlantic Ridge and the Mariana Trench.

Abstract

This study presents the impact-antipodal-interference hypothesis as a new model of planetary-scale crustal deformation.

By analysing the distribution and properties of three megastructures - the Mariana Trench, the Mid-Atlantic Ridge, and the Amazon Basin - it is demonstrated that their formation may be linked to large-scale cosmic impacts and the seismic wave interference occurring within Earth's volume.

The methodology included analysis of satellite data (GEBCO, GRACE, GPlates), global-scale seismic wave modelling, and comparisons with analogous phenomena on Mars, Mercury, and the Moon.

The results indicate geometric, physical, and geophysical consistency between the Mariana Trench, Mid-Atlantic Ridge, and Amazon Basin as consequences of planetary lithospheric rearrangement induced by cosmic impacts.

The hypothesis has been formulated in a way that allows empirical falsification and validation. Its confirmation would open new research directions in Earth and planetary sciences, leading to a shift in the current geodynamic paradigm.

Recommendations for further studies include deep sediment drilling, advanced seismic wave modelling, and extended geochemical analyses.

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