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Original Research Paper

Geomagnetic Anomalies: Lineaments

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Abstract: Geomagnetic anomaly maps can be interpreted according to either (i) To the electromagnetic (e.m.) Induction by the solar wind that generates telluric currents aimed to oppose the geomagnetic field originated by the deep geomagnetic dynamo, or (ii) By stray currents that outflow from the deep Earth's circuitry. The results correlate with other morphological, geodynamic, and tectonic features, which represent a tool for the investigation of Earth's interior. A few case studies are illustrated. It is thus shown that formerly unexplained morphological features displayed by geomagnetic anomaly maps can be justified in the framework of the planetary electrical circuit of air-earth currents.

Keywords: Geomagnetic Anomalies, Lineaments, Telluric Currents, Case Studies, Africa, Scotia Arc, Florida and Gulf of Mexico

Introduction

An accompanying paper (Gregori *et al.*, 2024d) addresses the "double-eye" features of geomagnetic anomaly maps that are a frequent occurrence in every volcanic area. These are interpreted in terms of DC currents on top of sea-urchin spikes. Another frequent unexplained feature deals with lineaments red/blue for positive/negative geomagnetic anomalies, which are generally observed and that are indicative, maybe, of a steady or in any case variable over long time intervals, but persistent action by deep telluric currents that, on the long time-range, orient the magnetic components of the crust.

For the sake of completeness, let us mention a few items related to the surge tectonics model (Meyerhoff and Meye, 1972; Meyerhoff and Meyerhoff 1974; Meyerhoff *et al.* 1996), i.e., speculating about stream flow processes that occur in the lithosphere, which ought to simulate, perhaps, some features similar to the lineaments that are here considered. Meyerhoff did not necessarily speculate much about electric currents, at least in his writings.

He expressed more conventional terms of mass (kinetic) transport of classical physics, i.e., he relied on fluid dynamics applied to solid Earth, analogously to fluid dynamics applied to the oceans or to the atmosphere. Conversely, he considered e.m. phenomena an ancillary driver. In any case, he must have assumed that e.m. energy was involved in leaving magnetic signatures. In any event, he indicated that these magnetic lineaments mostly represent susceptibility contrasts of magnitude and do not necessarily represent reversals of the global magnetic Field (FR). However, he agrees that these are more likely related to local magma and/or mantle currents (geo streams) and are not ridge parallel in many cases. DSDP results never confirmed the existence of these global reversals, as only a few boreholes reached what is considered a magnetic basement, and the ones that did, were not able to extract a sample in situ, i.e., oriented in its original position. Many magnetic surveys from ships or even planes use scaler magnetometers, which cannot determine magnetic direction. They only measure magnitude and even the ones that used vector magnetometers are not measuring the B of deep Earth rock. Conversely, they are measuring B at whatever altitude they are located. They use what is called downwards continuation (i.e., a mathematical trick) to project stronger values at depths greater than what is measured at altitude (airborne) or sea surface (marine).

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For instance, Quinn's data (Quinn *et al*., 2024) do not show FRs and one would not expect to detect FRs in orbital space. This is another tectonic hoax perpetuated by the plate tectonic paradigm that must speculate that seafloor spreading creates new seafloor and provides continental drift/motions. According to Leybourne *et al*. (2024), the seafloor was magnetically reset (Curie temperature) during Arc Blast Birkeland currents that stripped off the lithosphere carving out the seafloor. That is, continents should not really move large distances, except when thrust faulting due to Arc Blast or some large bolide impact, while during the rest of the time they vibrate maybe shifting slightly. Thus, a global scale rotating plasma (electric) current leaves the double layer signature, i.e., charge vs. lack of charge resulting in a susceptibility contrast. It should be stressed, however, that all these models can explain some lineament features. However, they do not explain the main morphological feature, which is the main focus in the present paper, i.e., red/blue lineaments in one hemisphere that look reversed blue/red in the opposite hemisphere Fig. (1).

Reference is made to the serpent sphere (Gregori and Hovland, 2024; Gregori *et al*., 2024a-b), which is a highly conductive layer at the base of the crust. The ALB (asthenosphere lithosphere boundary) is the upper boundary of the serpent sphere Gregori *et al*. (2024a-b). It is reasonable to expect that this conducting layer is crossed by intense currents that tend to oppose the e.m. induction action by the solar wind.

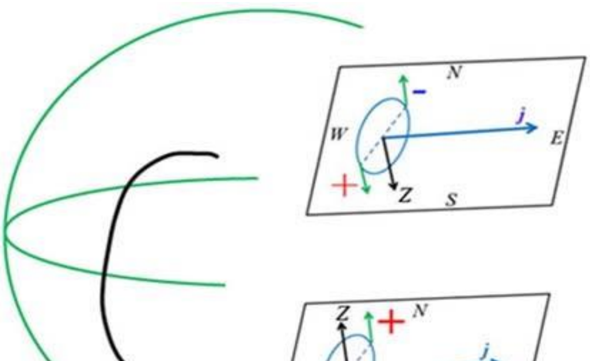

Fig. 1: The cartoon shows both the Earth and the geomagnetic equator in green lines. The black line is a geomagnetic field line. A supposedly eastward telluric current j originates an anomalous perturbation, of opposite sign in the two hemispheres of the vertical component Z. A positive anomaly is denoted in red and a negative anomaly is in blue. One should observe on the geomagnetic anomaly maps red/blue alignments, roughly running east-west at constant latitude, with a red strip closer to the equator

Another expected effect is associated with some comparably shallower large regions of telluric currents. Since these currents attempt to oppose the planetary geomagnetic field B of deep origin, these patterns in restricted unperturbed regions are expected to look like large blue patches in the geomagnetic anomaly maps.

We show examples of the sum of both these features, which are generally unexplained and that cannot be simply interpreted in terms of local rock magnetization or electrical conductivity anomalies, as every local property of this kind ought to be irregularly distributed, rather than have regular patterns.

The sea-urchin spikes derive from the propagation of endogenous energy for the deep Earth interior through the Earth's surface (Gregori, 2002; Gregori *et al*., 2024a-b) and, for a concise summary, (Gregori *et al*., 2024d).

A geomagnetic anomaly map is drawn, starting from a map of one given magnetic element (i.e., one component of the geomagnetic field B, or its total intensity F). Then, one chooses the seemingly best model for the planetary deep-origin B for isolating their residual, which ought to be representative of the magnetization of the crust. The residual map is the "anomaly map". Therefore, some arbitrariness is involved, as different maps display comparative differences. No map, however, represents the best possible choice, as the quality of a map depends on the progressively increasing amount of the observed database. In any case, the geomagnetic anomaly maps, together with gravity maps, seismological maps, and the general tectonic morphology, are the fundamental observational information used for investigating geodynamics and the origin and evolution of solid Earth. Therefore, we must interpret the geomagnetic anomaly maps by means of suitable and reasonable assumptions and approximations, in order to get evidence of physically indicative hunches.

Materials and Methods

The observational database relies on the geomagnetic anomaly maps. Their compilation is based on long and astuteanalysis extensively discussed in the original papers. As faras the method of analysis that is here applied, every region of the globe is interpreted according to the rationale of Figs. (1-3), although only a few indicative highlights are here shown,relying on two magnetic anomaly maps of the world.

One map was published by Purucker (2007). The same map is reported by Thébault *et al*. (2010), who call it the "World Digital Magnetic Anomaly Map" (WDMAM) and quote Korhonen *et al*. (2007). The anomaly field is plotted at an altitude of 5 km above the WGS84 ellipsoid. A distinction is made between near-surface compilations, satellite-based, and oceanic model data. The entire data set is displayed by the natural color scale (red = high, blue = low) with a shaded relief effect using artificial illumination.

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The original map is at a scale of 1: 50 *million*.

The other map, which is the main source here used, is the Global Earth Magnetic Anomaly Grid (EMAG2) compiled by satellite, ship, and airborne magnetic measurements, and is available at http://geomag.org and http://noaa.gov (Maus *et al*., 2008-2009; Müller *et al*., 2008; Sabaka *et al*., 2004).

Results and Discussion

Lineaments of Geomagnetic Anomalies: A Rationale for the Interpretation

Consider an eastward telluric current j that flows at approximately constant latitude Fig. (1). The effect has an opposing spin direction i.e., is specular in the two geomagnetic hemispheres. In the northern geomagnetic hemisphere, the vertical component is Z >0, i.e., the anomaly field (in green), which is produced by an eastward j, increases the total field F equatorward to j and it decreases the total field F poleward to j. A similar result is found with a reversed sign in the southern geomagnetic hemisphere, where Z>0.

In fact, the identical rationale applies to every telluric current, with any direction Fig. (2). That is, in the northern geomagnetic hemisphere, the vertical component Z >0 which is produced by j, is positive on the right side of j. In contrast, on the left side of j, the vertical component is Z >0.

A similar result holds in the southern geomagnetic hemisphere, where the signs are exchanged between the right and left sides relative to j.

Suppose that some mean eastward telluric current j has been the leading current during some relevant time interval of the past and still at present. One ought to observe red/blue lineaments in the planetary maps of the geomagnetic anomalies. In general, at every location, the red/blue lineaments are indicative of peculiar local features that determine some typical mean direction of j during some long time interval. In any case, all observational matters of fact are unquestionable and denote that, during some geological time lag, a mean flow of j determined the formation of the observed red/blue lineaments.

The mean observed eastward telluric currents j are tentatively justified by the following argument Fig. (3). The Earth's dipole moment M is oriented southward Fig. (3a) and can be symbolically represented by an equivalent circuit composed of a loop L of current Fig. (3b). When the solar wind interacts with the Earth owing to electromagnetic (e.m.) induction and to the Hamilton variational principle (Gregori *et al.*, 2024c) the solar wind attempts to minimize the effect of M. This means that the result amounts to generate a mean current opposite to L Fig. (3c).

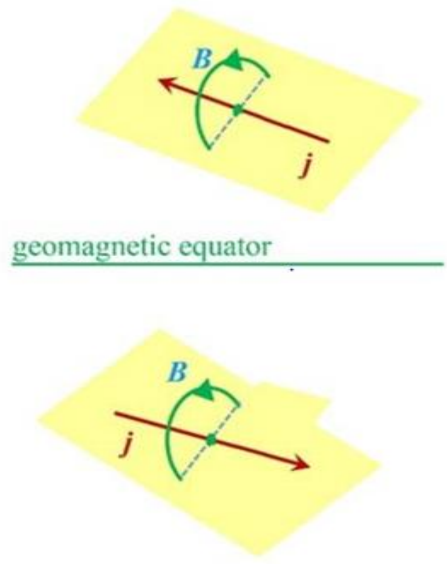

Fig. 2: A general telluric current j generates an anomaly with Z 0 on the right side of j in the Northern Hemisphere (NH) and an anomaly with Z 0 on the left side of j. In the Southern Hemisphere (SH), the signs of the Z anomaly are reversed between the right and left sides of j

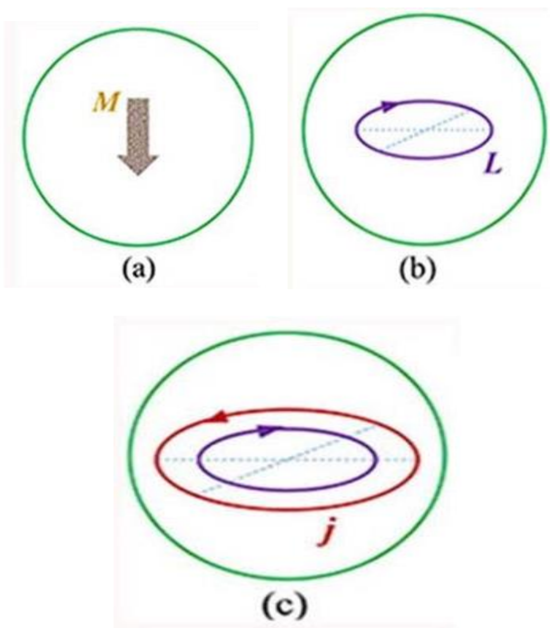

Fig. 3: The Earth is shown in green; (a) The geomagnetic field has a moment M; (b) In terms of an equivalent circuit, M can be substituted by an ideal loop L; (c) The e.m. induction by the solar wind attempts to oppose as much as possible and as an average effect on some long time lags the current that flows in the loop L. Thus, it generates a telluric current j in the serpent sphere that is approximately concentric and opposite to the L current. Hence, during a normal "chron", j is eastward and, during a reversed "chron", j is westward

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During a period ("chron") of normal field orientation, the induced current is eastward and it is westward during a reversed "chron". At present, we are during a long-lasting "chron" (~700 ka). Therefore, a reasonable guess is that the present red/blue lineaments refer to processes that occurred during the last long "chron". In addition, as it is well known, no statistical analysis of the time series of FRs afforded to evidence any regularity or periodicity. According to the interpretation here given (Gregori *et al.*, 2024d), an FR is caused by an erratic encounter of the Solar System with a dense cloud of interstellar matter. Therefore, all phenomena that eventually happened during the long time lag preceding the last FR are unlikely to be reckoned to the present observed red/blue lineaments (Leybourne *et al*., 2024).

In the case of magma effusion (like lava flow or pluton), the crustal magnetization depends on the polarization of B at the time of eruption. Otherwise, erosion generates fragmented material that is deposited in sediments aligned according to the local B. Hence, the evidence of mean eastward telluric currents ought to refer to the crustal fragmented material that accumulated in sediments during some time-lag of the last "chron".

In any case, the phenomenon is quite intricate. For completeness's sake, we remind you about some other investigations of linear morphologies of the crust. 1986 (Smoot and Heffner, 1986) showed the first NW SE trending of the Kashima Fracture Zone (FZ) in the NW Pacific. After that, other areas were investigated, such as the Marcus-Wake seamounts and guyots and their relation to the Dutton Ridge (Smoot, 1989) and the plate-wide Pacific trends of orthogonal fracture intersections (Smoot, 1994). Fracture zones were shown to cross to the western Pacific trenches, such as (Smoot, 1995; 1998a) the Chinook Trough, which is a trans-Pacific fracture zone.

In the Darwin Rise in the western Pacific, Guyot Heights traces the trans-Pacific Mendocino fracture zone, (Smoot 1997). Many seafloor experts already knew about the Emperor Seamount chain and the Adak and Amelia fracture zones in the Gulf of Alaska. The GEOSAT lineaments were used and compared to total coverage bathymetry (Leybourne and Smoot, 1997). The stage was set for examining entire basins between $72°N$ and $72°S$ worldwide. The focus was on examining (i) Vortex structures on the world-encircling vortex street (Smoot, 1997), (ii) Magma floods, microplates and orthogonal intersections (Smoot, 1997), (iii) WNW-ESE Pacific lineation's (Smoot, 1998b) and (iv) Orthogonal intersections of megatrends in the Mesozoic Pacific Ocean basin (Smoot, 1999).

Upon considering the trends established and by including the accurate bathymetry a multitude of trends was displayed. Thus, NNW-ESE megatrends were shown for the north and central Pacific basin (Smoot and Leybourne, 2001; Smoot and Choi, 2003). By including the previously known NE Pacific Moonless Mountains and the NE-SW trending of four seamount chains to the north of the Hess rise it was possible to construct such a diagram and to refute any sort of organized motion of the lithosphere in the Pacific basin (Smoot, 2012). Around that time "the persistent mantle plume myth" was explored (Anderson, 2013). The question was: do mantle plumes exist? A later e.m. synthesis of this problem was explored with the Stellar Transformer concept (Leybourne *et al*., 2017; Leybourne and Gregori, 2020) resulting in the examination of "Orthogonal Megatrend Intersections" as "Coils of a Stellar Transformer" (Smoot and Leybourne, 2020). We stress, however, that a FZ is physically other than an alignment on a geomagnetic anomaly map.

Observed Case Histories

Concerning the geomagnetic anomaly maps, every region of the globe can be analyzed according to the rationale of Figs. (1-3). Only a few indicative highlights are here shown, relying on two magnetic anomaly maps of the world.

One map was implemented by Purucker (2007). The same map is reported by Thébault *et al.* (2010), who call it the "World Digital Magnetic Anomaly Map" (WDMAM) and quote Korhonen *et al.* (2007). The anomaly field is plotted at an altitude of 5 km above the WGS84 ellipsoid. A distinction is made between near-surface compilations, satellite-based, and oceanic model data. The entire data set is displayed by the natural color scale (red = high, blue = low) with a shaded relief effect using artificial illumination. The original map is at a scale of 1: 50 $million$.

The case histories here reported in detail rely, rather, only on the other map, i.e., the Global Earth Magnetic Anomaly Grid (EMAG2) compiled by satellite, ship, and airborne magnetic measurements. The map is available at http://geomag.org and http://noaa.gov (Maus *et al*. 2008-2009; Müller *et al*., 2008; Sabaka *et al*., 2004).

A few major case histories are here shown. Fig. (4) is a detail of EMAG2 dealing with Arabia, India, and the Sunda arc. Some general trend of east-west lineaments is evident. Conspicuous band thickening is shown, beginning in Iraq/Iran, through the Himalayas, through Northern China and Japan. This is, maybe, correlated with the Moroccan mega shear (Bemmelen, 1972) that, according to Warm Mud Tectonics; (WMT) (Gregori, 2002; Gregori and Leybourne, 2020; Gregori *et al.*, 2024a), is a giant mega syncline crossing from Morocco through Japan. In addition, see the remarkable red/blue alignment in the Sunda archipelago.

In contrast, in the Atlantic Ocean, the geodynamic and tectonic features are dominating Fig. (5). Intense telluric currents seem to flow in the crust, parallel to the MAR (Mid Atlantic Ridge), which is one edge of the tetrahedron that represents an alignment of sea-urchin spikes (Gregori and Leybourne, 2020).

Some regions give evidence of thicker red/blue bands, such as the Adriatic Sea/Balkan Peninsula, in the Northern Venezuela area, and in some extended regions in North Africa, which is part of the aforementioned Morocco/Japan mega syncline.

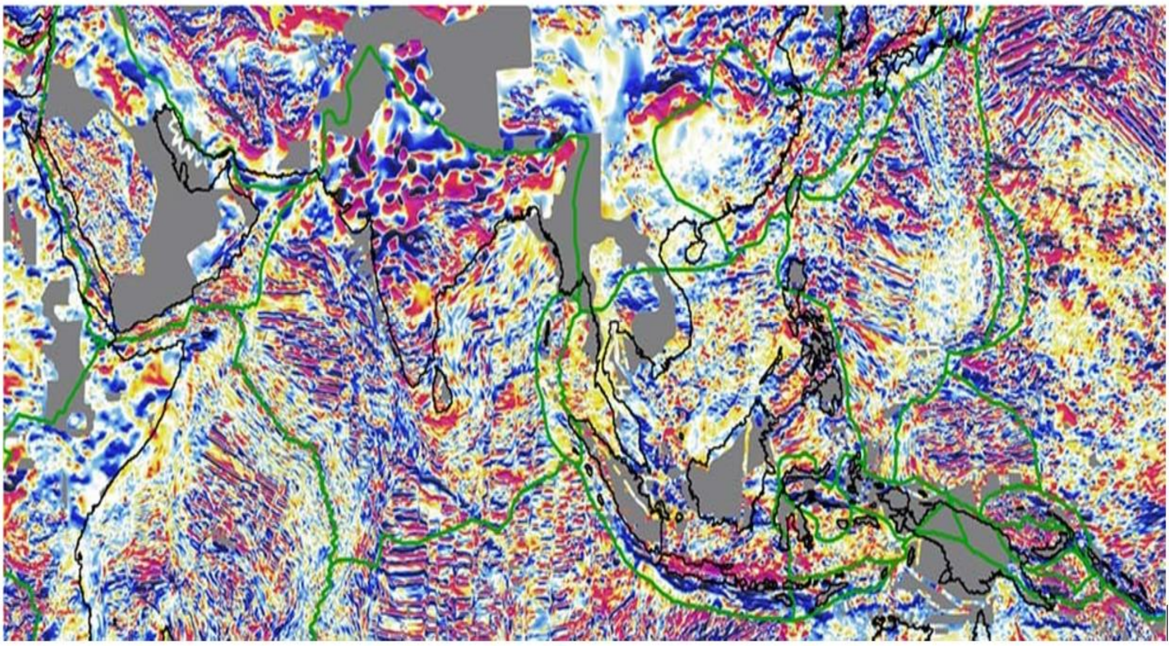


Fig. 4: Detail of EMAG2 dealing with Arabia, India, and the Sunda arc. See text. NOAA copyright-free policy

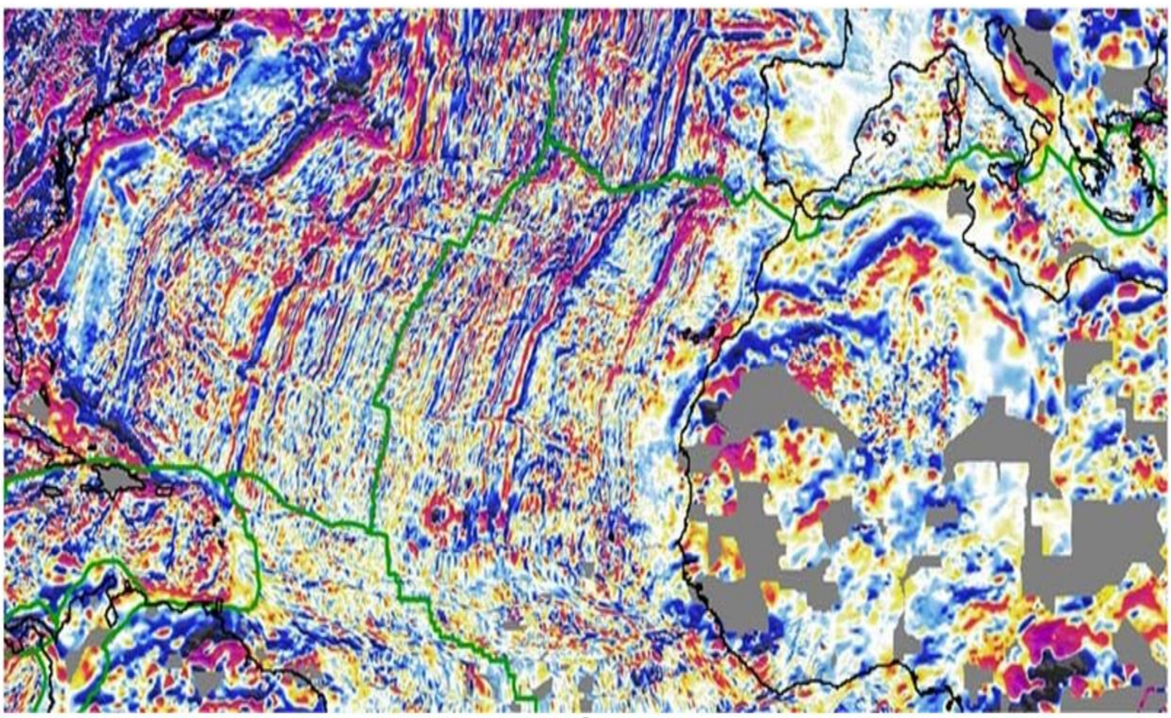


Fig. 5: Detail of EMAG2 dealing with central Atlantic. NOAA copyright-free policy

Africa seems to be the continent with the thicker lithosphere, denoting a comparably stronger link with the mantle (Chapman and Pollack, 1975; Pollack and Chapman, 1977a-b; Pollack *et al*., 1993). A long interdisciplinary discussion ought to refer to the whole set of morphological features of Africa.

For brevity, the focus is here only on geomagnetic anomalies. Fig. (6) shows a detail of EMAG2 and Fig. (7) addresses a few features that are concisely illustrated as follows.

Feature No. 1 is Zaïre's anomaly, clearly evidenced in Fig. (8). Note that the comparative close location of Feature No. 7 (Bangui Magnetic Anomaly) may envisage that, perhaps, Features No. 1 and No. 7 are the signatures of a unique large anomaly.

Feature No. 2 is analogous, although less extended.

Feature No. 3 shows a complicated pattern that displays two parallel red/blue double lines, beginning from the Canary Islands and Western Sahara, and that after a few bifurcations-join anew into a unique line at Suez and run northward until (maybe) joining the Iraq/Japan alignment. This feature approximately coincides with the Moroccan mega shear and is only slightly displaced southward, with respect to Earth's surface evidence. A relevant perturbation is caused by the rapid clockwise rotation of Anatolia into the Æ gean Sea.

Feature No. 4 is a similar doublet beginning in Guinea and Sierra Leone.

Feature No. 5 is analogous to feature No. 3. It is composed of 3 or 4 doublets crossing through South Africa and Namibia.

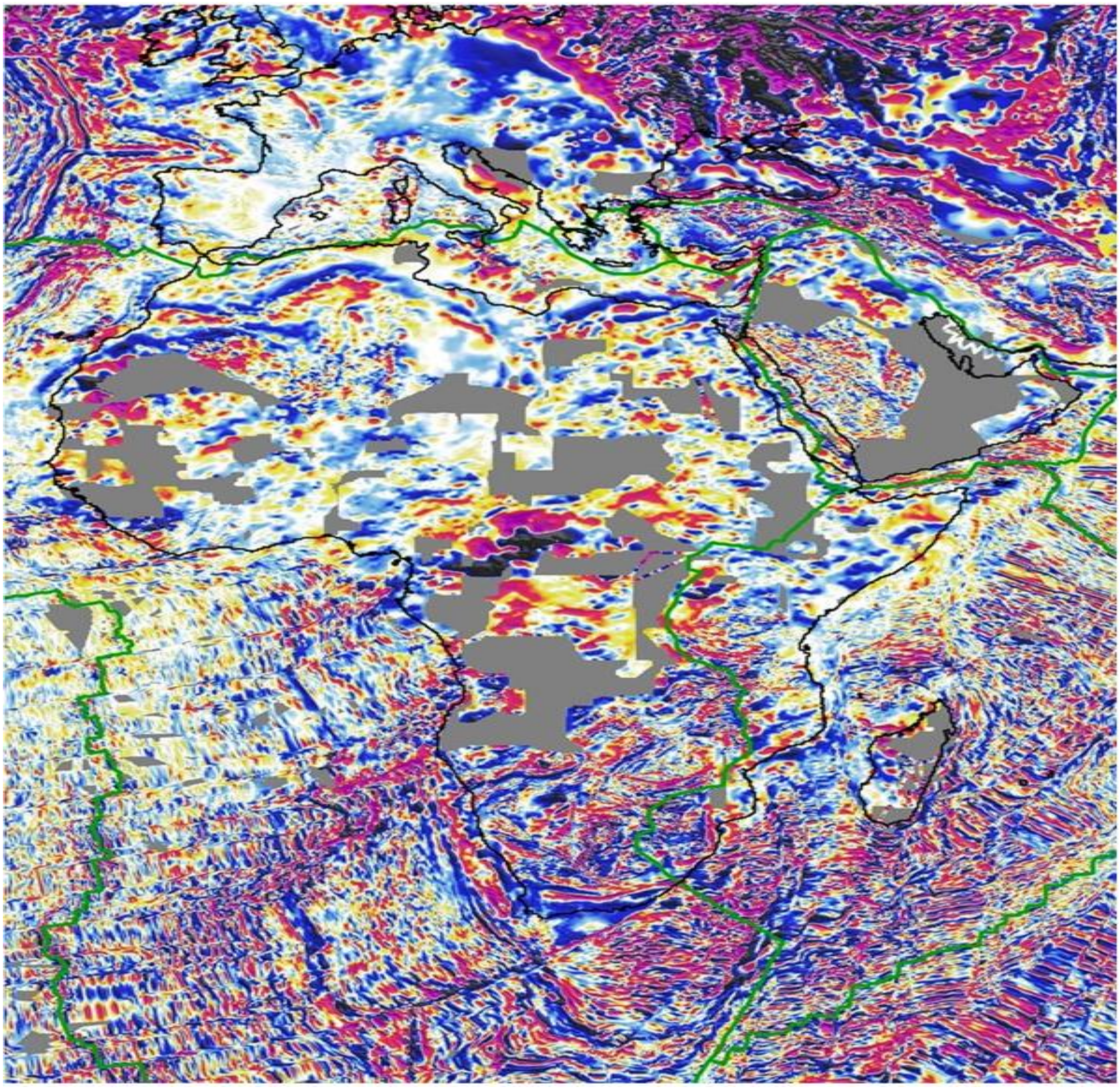


Fig. 6: Africa and surroundings in EMAG2. See text. NOAA copyright-free policy

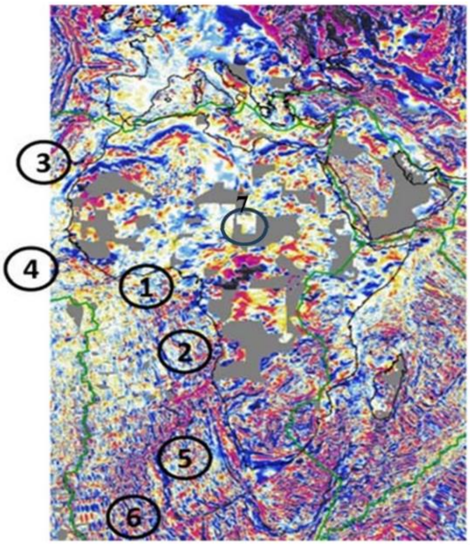
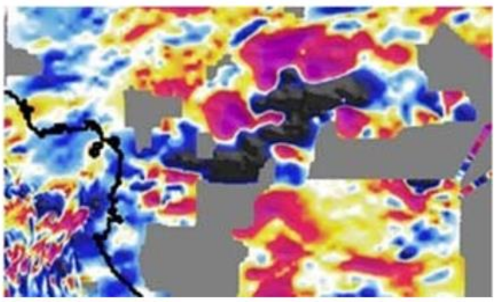
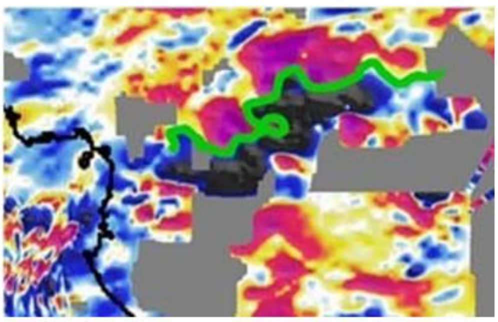


Fig. 7: Africa and surroundings in EMAG2. The same as Fig. (6) with superposed the indication of six peculiar features. See text. *NOAA* copyright-free policy



(a)



(b)

Fig. 8: Zaïre geomagnetic anomaly map, a detail of EMAG2; (a) Original datum being a detail of Fig. (6); (b) The same with superposed a semi-transparent green band to indicate the axis of the double-eye feature, corresponding to the Cameroon Volcanic Line (CVL). See text. NOAA copyright-free policy. This feature is, maybe, connected with the Bangui anomaly

Feature No. 6 shows a curious "inverted V" pattern found on the ocean floor, south of South Africa. This feature should be considered in the framework of the justification of the planetary Mid-Ocean Ridge (MOR) network, which is associated with the deep conducting tetrahedron (which is an alignment of sea-urchin spikes; Gregori and Leybourne, 2024). Note the curious pattern that corresponds to the southern tip of Africa, which is characterized by a high density of diamond-bearing kimberlites and by a high atmospheric density of CO_2, which persists in every season e.g., (Gregori, 2020) and references therein), in addition to displaying a close correlation with the DUPAL anomaly of the isotopic chemism of basalt (Gregori *et al*., 2024a).

Feature No. 7 is the Bangui Magnetic Anomaly, which is centered at Bangui, the capital of the Central African Republic. The magnetic anomaly is roughly elliptical, ~700 km ×1,000 km, and covers most of the country, making it one of the "largest and most intense crustal magnetic anomalies on the African continent" (Wikipedia).

Conclusion

These indications are only a concise premise for a much more extensive and far-looking discussion that, owing to brevity, we cannot report in the present paper.

Telluric currents, however, can also flow inside ocean water, which has an electrical conductivity σ that is ~40,000 times larger than dry rocks (Kucks *et al*., 1986) and oceans are the most important conductivity anomaly.

The mean pattern is therefore a large or near global double-layered spherical condenser. One conductor is the ionosphere, while the atmosphere is an insulating layer. Oceans are a conductor, while the deep lithosphere and dry rocks are an insulating layer, with a layer underneath of great conductance represented by the serpent sphere. The upper boundary of the serpent sphere is the ALB (Gregori and Hovland, 2024; Gregori *et al*., 2024d). This huge condenser system responds to the e.m. induction by the solar wind.

Concerning additional features, Fig. (9) shows, e.g., the geomagnetic anomaly of the Scotia Arc, where the red/blue lineaments associated with the Antarctic Peninsula are caused by the σ contrast between ocean water and ground. The large clockwise rotation of South America was the likely origin of the Scotia Arc, which, broke the Circum-Antarctic MOR (Smoot and Leybourne, 2020) while rotating around a kingpin (see below).

The Gulf of Mexico is a singular case history, as it displays a huge blue patch, which envisages (maybe) a "hack" surviving after the huge Chicxulub impact (Gregori and Leybourne, 2024) and the related discussion). In fact, see the huge blue patch roughly located in the Gulf of Mexico and in the surrounding areas Fig. (10), which is identical to Fig. (10) (Gregori and Leybourne, 2024).

This huge blue patch can be the "kingpin" associated with the impact of the Chicxulub astrobleme. Also, note the large lineaments north of the blue patch. Refer to the extensive discussion in (Quinn *et al*., 2024).

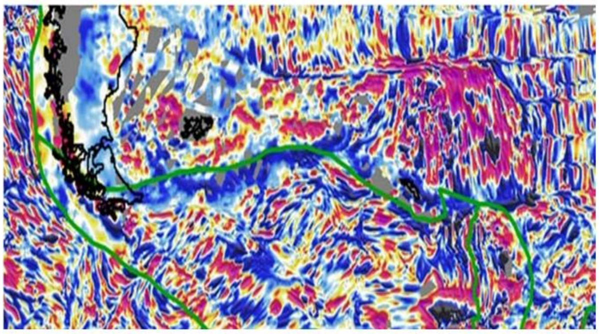


Fig. 9: Scotia arc detail in EMAG2. See text. unpublished figure

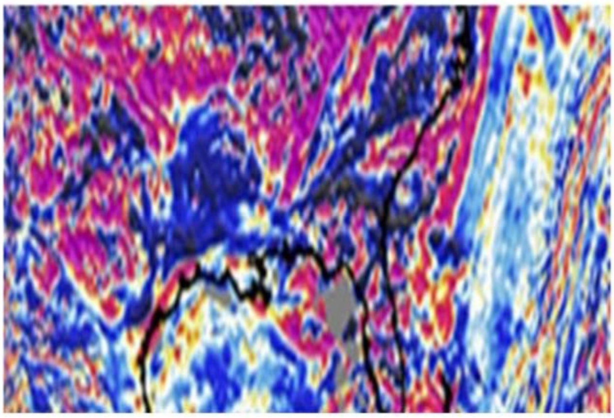


Fig. 10: Geomagnetic anomalies of the region surrounding Florida. EMAG2 detail. For other details, (Gregori *et al*. 2024a-b; Gregori and Leybourne (2024). Note the large blue patch on the left side portion of this map. See text. NOAA copyright-free policy

In addition, we could give a list of much evidence, although not here given, about morphological features that seem to be closely related to the sea-urchin spike mechanism. In fact, every item ought to request a long discussion of the correlation with local morphological features.

Summarizing, in general and in any case, the sea-urchin spike pattern and the electric currents in the asthenosphere, envisage an unprecedented criterion suited to interpret the geomagnetic anomaly maps, for possible correlation with other geophysical evidence.

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Author's Contributions

Giovanni Pietro Gregori: Main responsibility.

Bruce Allen Leybourne: Contribution with relevant discussion.

Ugo Coppa: Contribution with relevant discussion.

Giuseppe Luongo: Contribution with relevant discussion.

Ethics

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

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