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PAPER CHECK · GEOMAGNETISM

A 2006 study found Earth's dipole nearly steady before 1840; later studies are split

Gubbins, Jones and Finlay combined compass readings from ships' logs with 315 measurements from old fires and lavas, and found the dipole almost unchanged from 1590 to 1840: 2.28 ± 2.72 nT a year, against about 15 after [1 pp. 900–901]. One of them re-analysed the same data in 2008, found a steady dipole and a 15 nT-a-year fall almost equally likely and judged no change the most probable [3 Abstract][3 pp. 5, 10]; later studies range from no change, or slight growth [11 §5.5.2], to 12–16 nT a year [7 p. 78][8 pp. 1592–1593]. S0's special report cited the paper as "Mid-1800s Pole Shift Began" [2]; it never mentions a pole shift [1].

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OUR ANALYSIS marks our own reasoning and calculations, including our runs of the open field models gufm1, COV-OBS.x2, CALS10k.2, ARCH10k.1, HFM.OL1.A1, pfm9k.1a, arhimag1k and SHA.DIF.14k, and the verdicts are our assessment. Everything else comes from the numbered sources; for the paper [1], p. gives a page of *Science* 312 (900–902), and for S0's special report [2], times are positions in the video.

One careful reconstruction found the dipole nearly steady before 1840; later ones split, and none speaks of a pole shift

OUR ASSESSMENT

2.28 ± 2.72

nT a year: how fast the axial dipole weakened over 1590–1840 in the paper's one-slope fit, against about 15 after 1840 [1 p. 901]

±42

nT a year: the bounds when one of its authors re-analysed the same 315 measurements in 2008 and judged no change the most probable; on those bounds a steady dipole and a 15 nT-a-year fall were almost equally likely [3 Abstract][3 pp. 5, 10]

−2 to +11

nT a year: the weakening before 1840 in six open field models by our analysis, from −1.7 (slight growth) to +10.8 by least squares over 1590–1840 (1600–1800 for SHA.DIF.14k), against about 17–18 after 1840 in those tied to measurements [21][24] and [20]

THE CLAIMS

UNCONFIRMED

Strength nearly steady 1590–1840

The paper: "We found that magnetic field strength was nearly constant throughout this time, in contrast to the later period." [1 Abstract]

One straight line through 315 archaeological and volcanic measurements gave 2.28 ± 2.72 nT a year [1 pp. 900–901]. One of the authors re-analysed the same data, found bounds of ±42 nT a year, with a steady dipole and gufm1's 15 nT a year almost equally probable, and judged no change the most probable [3 Abstract][3 pp. 5, 10]. Later studies split: a fall of 11–16 nT a year in three [4][7 p. 78] and [8 pp. 1592–1593], little change in two models [11 §5.5.2][10 Abstract], a dip and a recovery in another [9 §5.3]; a 2015 review calls it an open issue [5 §5.05.4.1.3]. See section 3.

TRUE

Reverse flux in south drove fall

The paper: the fall in strength "originated in patches of reverse magnetic flux in the Southern Hemisphere" [1 Abstract][1 p. 902]

Our re-run of two open field models reproduces the paper's split: the Southern Hemisphere carries essentially all of the fall since 1840 [1 p. 902]. A 2016 study calls the decay "driven by growth and migration of reverse flux patches in the southern hemisphere" [12 Abstract], and a 2018 study puts reversed flux at about two-thirds of the decay over 1880–2015: a large share, not the "almost all" of the paper's Fig. 5 caption [16][1 p. 901]. Another 2016 study credits most of the decay to flow in the core carrying flux, rather than to expulsion [13 Abstract]. Our own count gives anything from about a third to about all, depending on how it is made. See section 2.

OVERSTATED

Little to no change before 1840

S0's special report: "But detailed reconstructions of prior centuries showed little to no change in the field strength." [2 00:00:42–00:00:48]

A fair summary of this paper, whose authors write of a period of "little or no activity" before 1840 [1 p. 902]. But the report presents a contested result as settled. The paper's result is one average slope over 250 years, not a detailed history: with such data, its 2008 re-analysis says, "an average rate of change over a 250-year interval" is all that appears possible [3 p. 11]. Other studies find the dipole already weakening by 11–16 nT a year [4][7 p. 78] and [8 pp. 1592–1593], and a 2015 review calls the question open [5 §5.05.4.1.3]. See section 6.

MISREAD

Mid-1800s pole shift began

The report links the paper as "Mid-1800s Pole Shift Began" and says: "Whatever is happening began right there in the middle of the 1800s." [2 00:00:48–00:00:50]

The paper is about the dipole's strength and never mentions a pole shift, an excursion or a reversal [1]. The report's timing for the dipole's faster fall matches the paper's own account: a change in the core around 1800, then a change of pace close to 1840 that its authors read from the flattening of 1840–1860 [1 p. 902][3 p. 12]. But the magnetic poles were moving all through 1590–1840 too, by our analysis of gufm1 [15][21]: the mid-1800s did not start their movement. See section 6.

MISLEADING

No dramatic change before 1840

The report: "Before that we were not in a dramatic magnetic change as a planet." [2 00:00:53–00:00:55]

The field's direction changed at least as much in 1590–1840 as in 1840–1990: London's compass swung 36° between 1590 and 1820, the dipole's axis tilted about 7° further from the spin axis, and the north dip pole moved at about the same average pace, by our analysis of gufm1 [15][21]. It is the strength before 1840 that is in dispute [5 §5.05.4.1.3]. See section 7.

1 · THE PAPER

Compass readings from ships for the field's shape, 315 old fires and lavas for its strength, and one straight line

David Gubbins, Adrian Jones and Christopher Finlay of the University of Leeds asked how fast Earth's dipole weakened before 1840, when its strength was not yet measured, and where the faster fall after 1840 came from [1 pp. 900, 902]. It is a peer-reviewed Report in *Science*, received January 11, 2006, accepted March 14 and published May 12; the work formed part of Jones's undergraduate project [1 p. 902].

STEP 1

Directions

The field's shape comes from gufm1, a model built from about 365,000 historical readings of the compass and dip needle, most from ships' logs [15 Table 1][11 §1.3.1]. Directions are available from 1590, though inclination is scarce in the 17th century [1 p. 900].

STEP 2

Strength

315 laboratory measurements of the field locked into baked clay and lava dated 1590–1840, from a published compilation. Typical errors are about 4,000 nT, or 10%, with dating errors from a year to centuries, and the data are mostly from Europe, with very little from the Southern Hemisphere [1 p. 900].

STEP 3

Convert

A theorem says good directions fix the field's shape, so the ratio of each intensity to gufm1's prediction at its place and date, multiplied by gufm1's g_1^0 at that date, gives one estimate of the axial dipole [1 p. 900][3 p. 2].

STEP 4

One slope

The authors assume g_1^0 fell along a straight line from 1590 to 1840 and pin its 1840 value to gufm1's, which leaves one unknown, the slope, fitted by a maximum-likelihood method that allows for errors in both strength and age [1 pp. 900–901].

SLOPE, 1590–1840

2.28 ± 2.72

nT a year of weakening, with χ^2 = 258 for 314 degrees of freedom: a good fit to a straight line [1 p. 901]

AFTER 1840

about 15

nT a year, the average fall since measurements began; the authors' t-test separates the two rates with better than 99.999% confidence [1 p. 901]

SINCE 1840

about 5%

a century, the decay the paper starts from [1 Abstract]; the dipole moment in COV-OBS.x2 fell 5.4% a century over 1840–1990, by our analysis [20]

In the authors' words Verbatim; © AAAS, quoted for review.

> *"Here we assume that $g_1^0(t)$ fell linearly from 1590 to 1840 and fix its value at 1840 to be that of the historical field model."*
>
> Gubbins, Jones and Finlay [1 p. 900]

> *"This result is vulnerable to small systematic errors in the paleointensity data"*
>
> The data would have to read slightly low in early times; the authors found no sign of that by method, author or site [1 p. 901]

> *"periods of rapid fall, as at present, interspersed with periods of little or no activity, as during 1590 to 1840 A.D."*
>
> What the title's "erratic" describes [1 p. 902]

The authors also note that their result agrees with the archaeomagnetic model CALS7K.2, which has a slower decay of the dipole moment over 1600–1800 than over 1800–1950 [1 p. 902]. *Science* ran an accompanying Perspective by Masaru Kono; we could read only its record and a one-line index summary, which frames the result as the field's strength holding steady until the mid-1800s [19].

2 · WHERE THE FALL CAME FROM

The fall since 1840 comes almost wholly from the Southern Hemisphere, and our re-run reproduces that

The dipole can be written as an average of the vertical field over the core's surface, so the paper maps where its change comes from: over 1840–1980 the Northern Hemisphere's contributions cancel and the Southern Hemisphere's carry the fall, (−0.1, 16.2, 16.1) nT a year for the north, the south and the whole [1 p. 902].

What the paper reports

The growth and southward drift of patches of reversed flux in the Southern Hemisphere drive most of the fall; one patch first appeared around 1780 [1 p. 902]. Over 1590–1840, at its own 2.28 nT a year, the split is (−0.8, 3.1, 2.3), which the authors read as longitudinal drift rather than growth, and from the directions, which are good from 1700, they place the change in the south around 1800 [1 p. 902]. They attribute reversed flux "almost certainly" to the expulsion of toroidal flux through the core's surface, and write that "our present result suggests" a quiet period up to 1800 followed by active spells of expulsion [1 p. 902].

OUR ANALYSIS

We split g_1^0 exactly into normal and reversed flux in each hemisphere at the core's surface, using the paper's Eq. 1, on a 1° grid, in gufm1 [15][21] and in COV-OBS.x2, a model of the instrumental record since 1840 [20]. The four parts sum to the model's g_1^0 to within 0.004%. Over 1840–1980 we get (−0.31, 16.20, 15.89) nT a year in gufm1 and (0.01, 15.92, 15.92) in COV-OBS.x2: the paper's split. With gufm1 rescaled to 2.28 nT a year before 1840 (an exploratory run, not pre-registered), 1590–1840 gives (−1.2, 3.4, 2.3) against the paper's (−0.8, 3.1, 2.3).

How much of the fall reversed flux carries, by how it is counted (our analysis)

WHAT WE COUNT	GUFM1	COV-OBS.X2
Reversed flux in the south, 1840–1990	55% · 35%	17% · 30%
Reversed flux in the south, from 1880	57% · 30%	60% · 33%
All reversed flux, from 1880	67% · 28%	70% · 30%
Southern cells reversed at the end, 1840–1990	149% · 104%	164% · 99%

Each cell gives the share of the fall in g_1^0 with the field kept to degree 14, then to degree 8; "degree" is how much fine detail is kept. "From 1880" runs to 1990 in gufm1 and to 2010 in COV-OBS.x2. A share above 100% means other areas offset part of the fall.

OUR ANALYSIS

The first three rows book each 1° cell of the core's surface by the sign of its field, with the hemispheres split at the geographic equator, so a reversed patch that grows into weak normal flux shows partly as normal flux weakening. The last row counts every change in the southern cells that are reversed at the end, where the patches now are. Neither is the paper's own measure, which maps where the change is concentrated [1 p. 901]; between them the share runs from about a third to about all, so our count can't settle it. COV-OBS.x2's 17% comes from its first decades: its finest detail, degrees 9–14, carries 66.7 ×10⁹ nT² of power at the core's surface in 1840, against 24–29 from 1880 to 1950, a sign of small scales that the early data constrain poorly. We registered in advance that reversed flux in the south would carry at least half of the 1840–1990 fall in each model at both degrees; it did only in gufm1 to degree 14.

Constable, Korte and Panovska describe the dipole's decay since 1840 as "driven by growth and migration of reverse flux patches in the southern hemisphere" [12 Abstract]. Metman and colleagues, who draw a magnetic equator instead of the geographic one, attribute about two-thirds of the 1880–2015 decay to reversed flux (we read their abstract only, in an index copy) [16]. Finlay, Aubert and Gillet find that a planetary gyre's meridional transport, carrying normal flux toward the equator and reversed flux toward the poles, explains most of the decay since 1840, rather than expulsion, and call it difficult to show that reversed patches are growing as fast as the decay needs [13 Abstract][13 p. 1].

The southern origin holds up in every model we ran; how much of it is "reverse flux" depends on how it is counted, and a 2018 study puts it at about two-thirds.

Before 1840, reversed flux in the south of gufm1 stays below a quarter of its 1990 value, at most 20% to degree 14 and 23% to degree 8, as the paper says; that reading, registered in advance, held. But early field models are smoother than later ones because they rest on fewer data [15 p. 983][5 §5.05.4.2.2], and the first archaeomagnetic record from southern Africa, covering about 1000–1600, finds that intensities there "drop sharply" around 1300, which its authors tie to the same kind of flux expulsion [17 Abstract]. Our check of S0 News's research note on the South Atlantic Anomaly covers that feature's history.

3 · TWENTY YEARS ON

Later studies of the same question split, and a 2015 review calls it an open issue

Nobody measured the field's strength before the 1830s, so every estimate for 1590–1840 rests on archaeological and volcanic samples, which are scattered and uncertain; how their errors are handled moves the answer [3 p. 5][9 §1].

What later work found for the dipole before 1840, in date order

YEAR	STUDY	HOW	BEFORE 1840
2006	Gubbins, Jones & Finlay	315 intensities, gufm1's shape, one slope	2.28 ± 2.72 nT a year: "nearly constant" [1 p. 901][1 Abstract]
2008	Finlay, one of the authors	The same 315 data; full field inversions and a Bayesian comparison	Best fit 2.74 nT a year, with 67% bounds of ±42.27. Constant g_1^0 is "most probable", but the odds between gufm1's 15 nT a year and no change are 0.95 [3 Abstract][3 pp. 5, 10]. Finlay warns against reading it as evidence for a truly constant field, and says the 2006 error bar may be too small [3 pp. 5, 11]
2011	Suttie, Holme, Hill & Shaw	Errors treated as fractions of the field expected at each site	About 12 nT a year (11–15 in Laj and Kissel's summary), close to the rate after 1840; with errors scaled to the measured values instead, the low rate returns, which later authors call a bias toward low values. Unread by us [4]; as five later papers describe it [5 §5.05.4.1.3][8 p. 1592], [9 §1][14 p. 2] and [11 §1.3.1]
2015	Jackson & Finlay, review	—	The rate before 1840 "remains an open issue", needing more well-dated archaeomagnetic data [5 §5.05.4.1.3]
2018	Poletti and colleagues	129 high-quality intensities from 1590 on (81 before 1840), the 2006 conversion	12.5 nT a year over 1590–2009, a rate spanning 1840, in a steady fall since about 750 CE [7 p. 78][7 p. 82]; they call the 1840 break a "biased feature" of comparing direct with indirect data [7 p. 82]
2018	Hellio & Gillet	Two ensembles of models, archaeomagnetic data only and with lake sediments; no historical data	About 11 ± 3 and 16 ± 2 nT a year from 1700 to the present, rates spanning 1840, with a weak trend, perhaps slight growth, from 1000 to 1700 [8 Abstract][8 pp. 1592–1593]
2020	Senftleben, thesis (model arhimag1k)	Historical and archaeomagnetic data together, with no constraint on g_1^0 before 1840	Roughly constant over 1600–1840, rising slightly to 1700 [11 §5.5.2]
2021	Troyano and colleagues	Consistent regional data from western Eurasia, with gufm1's shape	Not a straight line: $\lvert g_1^0\rvert$ fell about 26 nT a year to a low of about 29,400 nT in the 18th century, then rose about 34 nT a year in the early 19th; other regional data can neither confirm nor refute it [9 §5.3][9 §6]
2021	Arneitz and colleagues (model BIGMUDIh.1)	Historical, archaeomagnetic and volcanic data in one inversion	A fall of about 2 μT (6%) over 1500–1600, then relatively stable until 1900; they call the dipole of this period "highly disputed" [10 Abstract]

We read these studies in full, except Suttie and colleagues (2011), which is paywalled and unread; Arneitz and colleagues (2021), read as the abstract the publisher deposited with Crossref; Senftleben's thesis, read in chapters 1 and 5 and §3.4; and the 2015 review, read in the sections cited. HistKalmag, a newer model that joins historical and archaeomagnetic data, gives no rate for 1590–1840 in its paper's text, and its coefficients are served only through a request form, which we didn't submit [28].

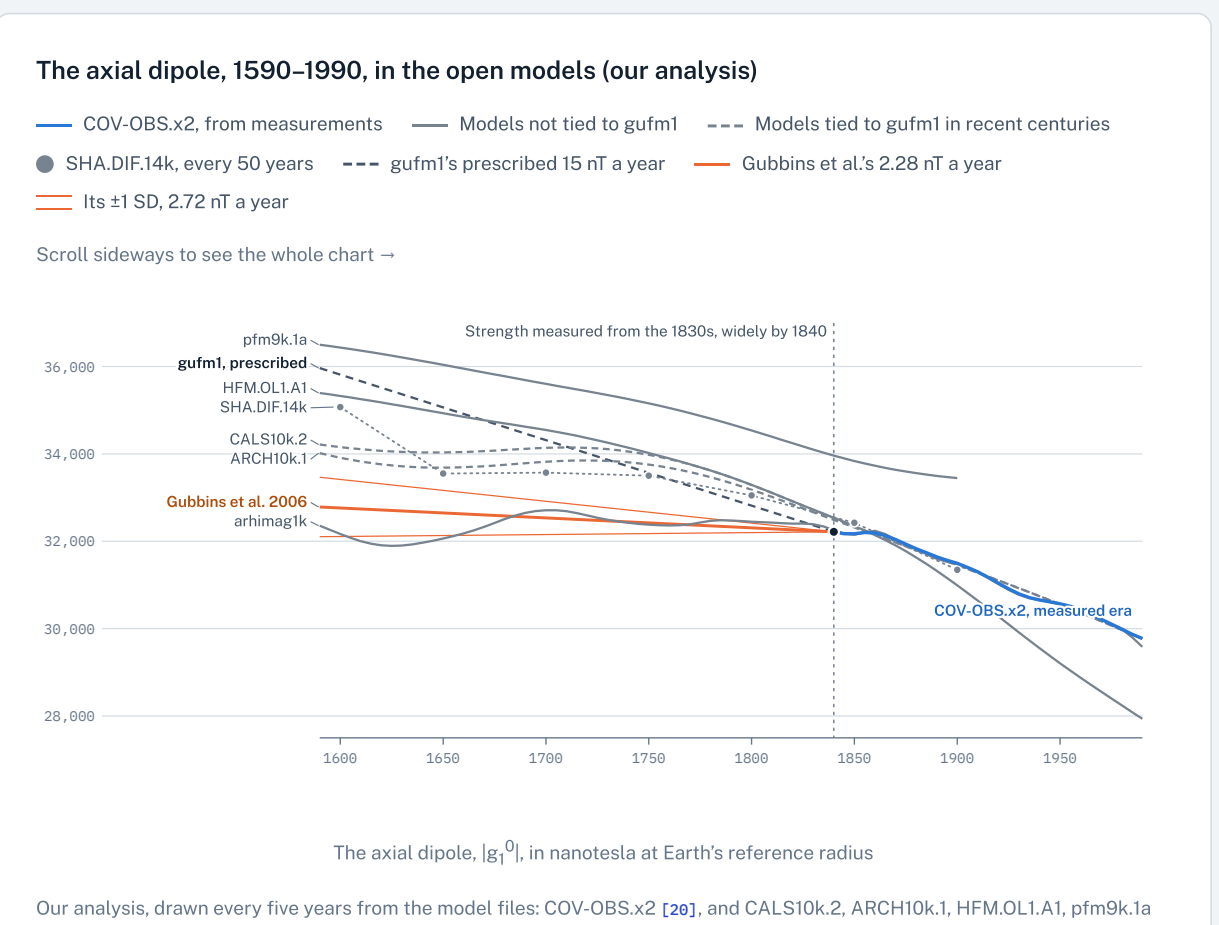
The 2006 result has been neither confirmed nor overturned: the same kind of data give anything from steady to a fall close to today's.

4 · THE OPEN MODELS

Six open field models put the pre-1840 fall anywhere from none to three-quarters of the measured pace after 1840

We ran the seven global models of the field before 1840 that we chose in advance, from their public files [21][24] and [20]. All of them fall more slowly before 1840 than after, except where they lack the instrumental record; but they share much of their data, so they are not independent witnesses [12 §2.1][22]. Most also have time steps too coarse to show a sudden change: 40 years in CALS10k.2, ARCH10k.1 and HFM.OL1.A1 [12 §2.1] and 50 in pfm9k.1a and SHA.DIF.14k, against 10 in arhimag1k [11 §3.4], 2.5 in gufm1 [15 p. 969] and 2 in COV-OBS.x2, as the files show [21][24] and [20].

The axial dipole, 1590–1990, in the open models (our analysis)



Our analysis, drawn every five years from the model files: COV-OBS.x2 [20], and CALS10k.2, ARCH10k.1, HFM.OL1.A1, pfm9k.1a and arhimag1k from GFZ's pymagglobal collection, CC BY 4.0 [21]; SHA.DIF.14k at its own 50-year epochs [24]. The straight lines are drawn from the published numbers: gufm1's prescribed fall of 15 nT a year [15 p. 967][3 p. 1] and Gubbins and colleagues' 2.28 nT a year, with thin lines one standard deviation, 2.72 nT a year, either side [1 p. 901], all from gufm1's value in 1840 [15]; in gufm1's file the fall averages 15.2 nT a year. No figure from any paper is redrawn. Hover or tap a line or dot for its values.

How fast the dipole weakened, model by model (our analysis)

MODEL	WHAT SHAPES IT BEFORE 1840	$\lvert G_1^0\rvert$, 1590–1840	PINNED AT 1840, AS THE PAPER FITS IT	$\lvert G_1^0\rvert$, 1840–1990	DIPOLE MOMENT, % A CENTURY, BEFORE AND AFTER 1840
gufm1	Directions only; g_1^0 prescribed at 15 nT a year [15 p. 967][3 p. 1]	15.2 (15.2)	15.2	17.1 (16.3)	3.9 · 5.3
COV-OBS.x2	**Instrumental data, from 1840** [20 Abstract]	—	—	**17.4 (16.3)**	— · **5.4**
CALS10k.2	Archaeomagnetic and sediment data; tied to gufm1 for 1600–1990, allowing for the lack of intensity data before 1840 [12 p. 81]	5.0 (6.8)	9.0	18.1 (18.4)	0.8 · 5.6
ARCH10k.1	Archaeomagnetic and volcanic data only; recent centuries tied loosely to gufm1; built as a tool for the other two [12 p. 80][21]	3.9 (6.1)	7.5	18.0 (18.1)	0.5 · 5.6
HFM.OL1.A1	Archaeomagnetic and sediment data only, no gufm1 [12 p. 81]	10.8 (11.4)	13.0	32.4 (30.7)*	2.6 · 10.3*
pfm9k.1a	Archaeomagnetic and sediment data, no gufm1; ends in 1900 [22][23]	9.9 (10.2)	11.1	8.5 (8.6), 1840–1900	2.2 · 3.3
arhimag1k	Historical and archaeomagnetic data together; g_1^0 left free [11 §5.5.2]	−1.7 (+0.4): slight growth	0.1	17.7 (17.8)	−1.2 · 5.5
SHA.DIF.14k	Archaeomagnetic and volcanic data; tied to gufm1 historically [9 §5.1]; 50-year steps, to 1900 [24]	8.2 (10.1), 1600–1800	—	—	1.9 · —

Weakening in nT a year: the least-squares slope, with the change from end to end in brackets, and the slope of a line pinned at the model's own 1840 value, as the 2006 paper fits its line; a minus sign means the dipole strengthened. * HFM.OL1.A1 has nothing tying its recent end to the measured field, and it falls about twice as fast as the measurements after 1840. The dipole moment is in % of the model's own 1840 value per century (SHA.DIF.14k, which has no 1840 epoch: its 1800 value), by least squares [21][24] and [20].

OUR ANALYSIS

How the models compare with the 2006 paper's one-standard-deviation range, −0.4 to 5.0 nT a year, depends on how the slope is fitted. By least squares, the measure we registered in advance, CALS10k.2 (5.0) and ARCH10k.1 (3.9) fall within it and arhimag1k grows; pfm9k.1a and SHA.DIF.14k fall at 5–10 nT a year, and HFM.OL1.A1, at 10.8, joins gufm1 in the class we registered as near gufm1's 15. Pinned at 1840, as the paper fits its line, CALS10k.2 and ARCH10k.1 fall at 9.0 and 7.5 nT a year, and their end-to-end rates, 6.8 and 6.1, are also outside the range; only arhimag1k is within the range or below it on every measure. In CALS10k.2 and ARCH10k.1 the fall speeds up from about 1730 and reaches the post-1840 average, about 17 nT a year, around 1790–1810. But a cubic spline on 40-year knots spreads each change over about 160 years, and in both models the fall after 1840 is tied to gufm1 [12 pp. 80–81][21], so it may reach back to about 1800, while arhimag1k, on 10-year knots, falls at only 1–3 nT a year from 1790 to 1830. gufm1's makers adopted a dipole decay that "fixes $g_1^0(t)$ to decay at a rate of 15 nT yr^{-1} for t < 1840", with its 1840 value set by the measured intensities [15 p. 967]. In the file the line falls at 15.06–15.33 nT a year in every decade from 1590 to 1840, close to 15 but not exactly: our registered test that it equals 15 to within 0.05 failed, and our registered search for the end of its straight line stopped at 1591, the first year tested. It slows at once after 1840, to 6.7 nT a year in the 1840s and 3.0 in the 1850s. Our code reproduces GFZ's own dipole series for CALS10k.2 to within 0.006 ×10²² A m² [25] and g_1^0 in 1990 to within 5 nT of the international reference value [26].

5 · WHERE THE RECORD STARTS

The measured record starts around 1840, and its first twenty years show almost no fall

Absolute intensity was first measured in 1832 [15 p. 959][6 Fig. 24], and measurements were widespread by 1840 [1 p. 900]. So 1840 is where the measured record of strength begins in earnest; the paper dates the change in the core to about 1800, from directions [1 p. 902], and its authors read the flattening of 1840–1860 as a real change of pace [3 p. 12].

1840–1860 OUR ANALYSIS

≈ 0

nT a year: the axial dipole's change in COV-OBS.x2, the model of the instrumental record (−0.4 by least squares); gufm1 has 6.7 and 3.0 nT a year in the two decades [20][21]

1860S–1980S OUR ANALYSIS

9–26

nT a year, decade by decade in COV-OBS.x2: 15 in the 1860s, 26 in the 1910s, 9 in the 1940s, 23 in the 1970s [20]. The fall itself has been uneven

1840–2020 OUR ANALYSIS

15.6

nT a year from end to end in COV-OBS.x2, or on the same basis 5.1% of the dipole moment's 1840 value a century [20]

Reading a change at the edge of the data

Finlay notes that the 2006 result, and Finlay's own, fit the "shallowing" of g_1^0 between 1840 and 1860 in gufm1 better than gufm1's 15 nT a year does [3 p. 11]. Finlay also warns that when an average differs between two intervals, it is tempting, and wrong, to conclude that the change happened rapidly at their boundary; but the 2006 authors placed the change close to 1840 "not on this basis", Finlay writes, but from "the clear shallowing" of g_1^0 between 1840 and 1860 and the changes in reversed flux that came with it, and its closeness to the boundary was "in their view simply an unfortunate coincidence" [3 p. 12]. The 2006 paper itself dates the change in the core to around 1800, from directions [1 p. 902].

OUR ANALYSIS

How strong the field was in 1590 depends on that early rate. On gufm1's convention $\lvert g_1^0\rvert$ in 1590 was 36,015 nT, 11.8% above 1840; at the 2006 paper's rate, 32,785 nT, 1.8% above. Against IGRF-14's 29,350 nT in 2025, the loss since 1590 is 18.5% or 10.5%, and since 1840 8.9% [26][21]. Either way it is far from the 55% loss that our check of field-loss figures rated False.

6 · WHAT S0'S SPECIAL REPORT SAID

The report presents a contested result as settled, and the paper as the start of a pole shift

S0's special report of November 9, 2026 dates the start of the field's decline to the mid-1800s [2 00:00:42–00:00:55], and its description links this paper as "Mid-1800s Pole Shift Began" [2]. Our review of the report checks the rest of it.

In the report's words From tactiq.io's automatic transcript, supplied by the site's owner.

> *"But detailed reconstructions of prior centuries showed little to no change in the field strength."*
>
> S0's special report [2 00:00:42–00:00:48]

> *"Whatever is happening began right there in the middle of the 1800s."*
>
> S0's special report [2 00:00:48–00:00:50]

> *"Before that we were not in a dramatic magnetic change as a planet."*
>
> S0's special report [2 00:00:53–00:00:55]

"Little to no change"

A fair paraphrase of the paper [1 Abstract][1 p. 902], and two later models also find little change [11 §5.5.2][10 Abstract]. But the report presents a contested result as settled. The paper's result is one average slope over 250 years, not a detailed history [3 p. 11]; other reconstructions find the dipole already falling by 11–16 nT a year [4][7 p. 78] and [8 pp. 1592–1593], and a 2015 review calls the question open [5 §5.05.4.1.3]. Overstated.

"Began right there in the middle of the 1800s"

For the dipole's faster fall, the report's timing matches the paper's own account: a change in the core around 1800, then a change of pace close to 1840 [1 p. 902][3 p. 12]; in the measured record the fall picks up around 1860 (section 5) [20]. But the paper says nothing of a pole shift; its subject is the dipole's strength [1], and the poles were moving before 1840 too (section 7). Calling it the start of a pole shift misreads it. Misread.

"Not in a dramatic magnetic change"

The field's direction changed at least as much in 1590–1840 as in 1840–1990 (section 7), and how its strength changed is exactly what is disputed [5 §5.05.4.1.3]. Calling the planet magnetically quiet before 1840 leaves out half the picture. Misleading.

The report describes a "dual line graph" [2 00:02:12–00:02:47] that matches Figure 5 of S0 News's research note 007, credited to an "internal GrokBot Team", whose flat stretch before 1840 is drawn from this paper's slope [27 Figure 5]; we did not see the report's graphics. Our check of the note reproduces that figure. Our pages on field-loss figures and the next excursion already describe the 1590–1840 steadiness as one reconstruction's.

7 · A BUSY FIELD BEFORE 1840

Before 1840 the compass swung, the dipole tilted and the poles moved

Directions were measured all through 1590–1840, and they barely depend on the strength assumed, because rescaling the field leaves them unchanged [1 p. 900]. Here is what gufm1 shows [15][21].

LONDON'S COMPASS OUR ANALYSIS

36°

its swing from 11.6° east in 1590 to 24.7° west in 1820; since 1840 it has turned back 19°, to 4.6° west in 1990 [21]

THE DIPOLE'S TILT OUR ANALYSIS

+7°

the geomagnetic pole moved from 85.4°N in 1590 to 78.7°N in 1840, and stayed within 78.5–79.1°N from 1840 to 1990 [21]

NORTH DIP POLE OUR ANALYSIS

6.9 vs 7.3

km a year, its mean pace in 1590–1840 and in 1840–1990: 1,730 and 1,095 km of path, in 10-year steps [21]

At Cape Town the compass turned 31° west between 1590 and 1840, a further 1.6° west by 1880, then 7.0° back east by 1990: a net 5.5° east since 1840. The dip pole sped up only after 1990, as our check of the note and our guide describe. Early arctic readings are sparse, and where data are few gufm1 leans on its smoothing [15 p. 983], so these pre-1800 pole positions are the least certain numbers here.

8 · NOT IN THE PAPER

The paper never mentions a pole shift, an excursion or a reversal

We searched the full text: "pole shift", "excursion" and "reversal" never appear, and "pole" appears only in "dip-poles", in the statement of the theorem [1 p. 900]. It describes a dipole that sometimes falls fast and sometimes rests [1 p. 902].

Later work on where the decline leads

Poletti and colleagues suggest that today's decline may be nearing its end, which they say tells against an imminent reversal [7 p. 82]. Constable and colleagues find today's decay not unusual against the last 10,000 years, after a dipole that was unusually strong for 3,000 [12 p. 86]. In a 2015 study, Laj and Kissel "tentatively suggest" that irreversible processes driving the geodynamo toward a polarity change may already have started, but that a reversal or an excursion should not be expected for 500–1,000 years [14 Abstract]; Brown and colleagues infer that the field is not in the early stage of either [18].

OUR ANALYSIS

A falling dipole is not a moving pole: the poles moved before 1840 and since (section 7). Our page on the next excursion finds that halving today's dipole would take centuries at any measured pace.

9 · LIMITS

What this check could and couldn't settle

No re-run with today's data

We planned to repeat the 2006 method on today's archaeointensity database, GEOMAGIA50, and registered its rules in advance. The database's query page could not reach its data on November 9, and its data come only through a query form, so the re-run was not done.

One study unread

Suttie and colleagues (2011) is paywalled. We give its result as five later papers describe it: about 12 nT a year, or 11–15 in Laj and Kissel's summary [4].

Abstracts only

We read Arneitz and colleagues (2021) and Tarduno and colleagues (2015) in their abstracts, Brown and colleagues (2018) in its significance statement, and Metman and colleagues (2018) in an index copy of their abstract, which we paraphrase [10][17], [18] and [16]. *Science*'s Perspective on the paper we know only from its record [19].

Models, not measurements

Every model's strength before 1840 rests on the same few hundred dated samples, smoothed over decades; gufm1's and arhimag1k's directions also draw on historical readings, about 365,000 of them in gufm1 [15 Table 1]. They disagree because that evidence is thin, which is the point of this page.

Two models out of reach

BIGMUDIh.1's files were on a server that didn't answer, and HistKalmag's come only through a request form. BIGMUDIh.1's pre-1840 behaviour we take from its abstract [10]; HistKalmag's paper gives no pre-1840 rate [28].

What would change these verdicts

01 A new compilation of well-dated archaeointensities from the 16th to 19th centuries, especially from the Southern Hemisphere, that settles the rate before 1840 either way.

02 A field model that joins historical and archaeomagnetic data and gives the same answer however its errors are weighted.

03 A passage in the paper, or in its authors' later work, linking the 1840 change to a pole shift, an excursion or a reversal.

These are our own judgments of what would change the verdicts, not forecasts from the sources.

10 · HOW WE WORKED IT OUT

One script, the public model files, and every number on this page

Every number tagged "Our analysis" comes from one standard-library Python script that downloads the public model files, checks them and writes its results to a JSON file. It reproduces the analyses we first ran under rules written in advance, and adds what a fresh review of this page asked for, marked in the file as added after review.

PY	**dipole_before_1840.py**	The checks; the rates in every model, with the slope pinned at 1840; the decade-by-decade fall; the 1590 field; the split by hemisphere and flux at the core's surface, counted several ways; London's and Cape Town's compass, the dipole's tilt and the dip pole in gufm1; and the chart's series · 34 KB
JSON	**dipole-numbers.json**	Every number from our analysis on this page, as the script writes it · 65 KB
TXT	**RULES_model_rates.txt** and **RULES_reverse_flux.txt**	The rules, each written before its own analysis was run. Some readings failed as registered: gufm1's fall before 1840 averages 15.2 nT a year, not exactly 15, and isn't straight at the registered tolerance; and reversed flux in the south carried at least half of the 1840–1990 fall in only one of four runs (section 2) · 6 KB and 3 KB
TXT	**RULES_geomagia_rerun.txt**	The rules for the GEOMAGIA50 re-run. Not run: the database was unreachable · 3 KB
PY	**model_rates.py** and **reverse_flux.py**	The numpy code we ran first under those rules, with its outputs, model_rates.json and reverse_flux.json. The standard-library script matches them, except that it divides the dipole moment's rate before 1840 by each model's 1840 value, as the rules say, where the numpy code used the 1590 value · 20 KB, 8 KB, 19 KB and 31 KB
TXT	**analysis-log.txt**	The SHA-256 of the rules, the inputs and every script and output, in the order they were made, with the fixes on the way and what the fresh review changed · 6 KB

Run it

It needs only Python 3. Run `python3 -I -B dipole_before_1840.py` in a folder of its own. The first time, it downloads its inputs, about 7 MB in all: gufm1 [15], the pymagglobal model files from GFZ's public GitLab [21], GFZ's check files [25], COV-OBS.x2 from DTU Space [20] and IGRF-14 from NOAA [26]. It identifies itself as factchecked-research/1.0 and checks each file against the SHA-256 of the copy we used. To include SHA.DIF.14k, extract `coeff_SHA.DIF.14k.dat` from its RAR archive with any archive tool and put it beside the script [24]. It takes about half a minute.

Related checks

- FALSE 55% of the field gone? The Disaster Cycle, Fact-Checked
- FALSE 15% gone, ten times faster? The Disaster Cycle, Fact-Checked
- UNSUPPORTED A magnetic pole flip in the 2040s? The Disaster Cycle, Fact-Checked

Sources

Bracketed numbers refer to this list. For the paper [1], read in full, p. gives a page of Science 312 (900–902) and Abstract its abstract. For S0's special report [2], times are positions in the video (hours:minutes:seconds), from the first to the last line of the transcript that holds the words quoted. For S0 News's research note [27], the locator names a figure. For the other sources, p. gives a page as printed, § a section, Table or Fig. a table or figure, and Abstract its abstract; where we read only an abstract or a record, the entry says so. Links checked November 9, 2026.

1 Gubbins, D., Jones, A. L., and Finlay, C. C. (2006). Fall in Earth's Magnetic Field Is Erratic. *Science* 312(5775), 900–902. Received January 11, 2006, accepted March 14, published May 12. © AAAS, all rights reserved: quoted for review, and no figure is redrawn. Full text, author-posted copy of the publisher's PDF, from co-author Christopher Finlay's publications folder at DTU Space; also its Crossref and PubMed (16690863) records. The paper has no supplementary material.

2 SpaceWeatherNews (S0) (November 9, 2026). SPECIAL REPORT: Pole Shift - Part 1. YouTube video, https://www.youtube.com/watch?v=m4S0pdDkgsk. Quoted from tactiq.io's automatic transcript, supplied by the site's owner; times are positions in the video. The label "Mid-1800s Pole Shift Began" is the report's own, on its link to source 1 in the video's description.

3 Finlay, C. C. (2008). Historical variation of the geomagnetic axial dipole. *Physics of the Earth and Planetary Interiors* 170(1–2), 1–14. © Elsevier. Full text, author-posted copy of the publisher's PDF, from the same folder.

4 Suttie, N., Holme, R., Hill, M. J., and Shaw, J. (2011). Consistent treatment of errors in archaeointensity implies rapid decay of the dipole prior to 1840. *Earth and Planetary Science Letters* 304(1–2), 13–21. Paywalled, and the publisher's site answered our tools with a challenge page, which we did not try to pass; unread. Described as five later papers report it (sources 5, 8, 9, 11 and 14): about 12 nT a year before 1840, or 11–15 in Laj and Kissel's summary.

5 Jackson, A., and Finlay, C. C. (2015). Geomagnetic Secular Variation and Its Applications to the Core. In *Treatise on Geophysics*, 2nd edition, vol. 5, 137–184. Elsevier. Sections 5.05.4.1.3 and 5.05.4.2.2 read, in the authors' copy from the DTU Space folder.

6 Jackson, A., and Finlay, C. C. (2007). Geomagnetic Secular Variation and Its Applications to the Core. In *Treatise on Geophysics*, 1st edition, vol. 5, 147–193. Elsevier. The caption of its Fig. 24 read, in the authors' copy from the DTU Space folder.

7 Poletti, W., Biggin, A. J., Trindade, R. I. F., Hartmann, G. A., and Terra-Nova, F. (2018). Continuous millennial decrease of the Earth's magnetic axial dipole. *Physics of the Earth and Planetary Interiors* 274, 72–86. CC BY 4.0. Full text, the publisher's PDF from HAL.

8 Hellio, G., and Gillet, N. (2018). Time-correlation-based regression of the geomagnetic field from archeological and sediment records. *Geophysical Journal International* 214(3), 1585–1607. Full text, from HAL.

9 Troyano, M., Gallet, Y., Genevey, A., Pavlov, V., Fournier, A., Lagroix, F., Niyazova, M., and Mirzaakhmedov, D. (2021). Analyzing the geomagnetic axial dipole field moment over the historical period from new archeointensity results at Bukhara (Uzbekistan, Central Asia). *Physics of the Earth and Planetary Interiors* 310, 106633. Full text, the accepted manuscript from HAL (CC BY-NC 4.0); § gives its sections. Its supplementary tables were not read.

10 Arneitz, P., Leonhardt, R., Egli, R., and Fabian, K. (2021). Dipole and nondipole evolution of the historical geomagnetic field from instrumental, archeomagnetic, and volcanic data. *Journal of Geophysical Research: Solid Earth* 126(10), e2021JB022565. Abstract only, as deposited with Crossref; a free copy in Norway's national research archive refused our script.

11 Senftleben, R. (2020). Earth's magnetic field over the last 1000 years. PhD thesis, University of Potsdam. The source of the model arhimag1k. Chapters 1 and 5 and §3.4 read.

12 Constable, C., Korte, M., and Panovska, S. (2016). Persistent high paleosecular variation activity in southern hemisphere for at least 10 000 years. *Earth and Planetary Science Letters* 453, 78–86. The paper of the models CALS10k.2, ARCH10k.1 and HFM.OL1.A1. CC BY-NC-ND 4.0. Full text, GFZ's copy in GFZpublic.

13 Finlay, C. C., Aubert, J., and Gillet, N. (2016). Gyre-driven decay of the Earth's magnetic dipole. *Nature Communications* 7, 10422. CC BY 4.0. Full text.

14 Laj, C., and Kissel, C. (2015). An impending geomagnetic transition? Hints from the past. *Frontiers in Earth Science* 3, 61. CC BY 4.0. Full text, cited as on our page When is the next magnetic excursion due?.

15 Jackson, A., Jonkers, A. R. T., and Walker, M. R. (2000). Four centuries of geomagnetic secular variation from historical records. *Philosophical Transactions of the Royal Society A* 358(1768), 957–990. The gufm1 paper. Full text, supplied by the site's owner from JSTOR; p. 959 and p. 967 give the first absolute intensities, in 1832, and the dipole's prescribed fall before 1840. Its model file is gufm1.txt, also in source 21.

16 Metman, M. C., Livermore, P. W., and Mound, J. E. (2018). The reversed and normal flux contributions to axial dipole decay for 1880–2015. *Physics of the Earth and Planetary Interiors* 276, 106–117. Abstract only, in an index copy (Semantic Scholar), so paraphrased.

17 Tarduno, J. A., Watkeys, M. K., Huffman, T. N., Cottrell, R. D., Blackman, E. G., Wendt, A., et al. (2015). Antiquity of the South Atlantic Anomaly and evidence for top-down control on the geodynamo. *Nature Communications* 6, 7865. CC BY-NC-SA 4.0. Abstract read.

18 Brown, M., Korte, M., Holme, R., Wardinski, I., and Gunnarson, S. (2018). Earth's magnetic field is probably not reversing. *Proceedings of the National Academy of Sciences* 115(20), 5111–5116. Significance statement only, as deposited with Crossref; cited as on our page When is the next magnetic excursion due?.

19 Kono, M. (2006). Ships' Logs and Archeomagnetism. *Science* 312(5775), 865–866. A Perspective on source 1. Record only, with a one-line summary in OpenAlex's index; *Science*'s site showed our tools a bot check, which we did not try to pass.

20 Huder, L., Gillet, N., Finlay, C. C., Hammer, M. D., and Tchoungui, H. (2020). COV-OBS.x2: 180 years of geomagnetic field evolution from ground-based and satellite observations. *Earth, Planets and Space* 72, 160. CC BY 4.0. With the model files COV-OBS.x2-int and COV-OBS.x2-int.shc (DTU Space), which state no licence; the same model file as on our page on field-loss figures.

21 GFZ Helmholtz Centre for Geosciences (2020–2025). pymagglobal: a python interface for global geomagnetic field models, model files gufm1, CALS10k.2, ARCH10k.1, HFM.OL1.A1, pfm9k.1a and arhimag1k (folder pymagglobal/dat), each CC BY 4.0, with their descriptions in the folder's README. We evaluated the files ourselves and did not run the package.

22 GEOMAGIA50 (GFZ Potsdam and partners). Available global models: the database's descriptions of CALS10k.2, ARCH10k.1, HFM.OL1.A1, pfm9k.1a and earlier models, read on November 9, 2026.

23 Nilsson, A., Holme, R., Korte, M., Suttie, N., and Hill, M. (2014). Reconstructing Holocene geomagnetic field variation: new methods, models and implications. *Geophysical Journal International* 198(1), 229–248. The paper of the model pfm9k.1a; not read, cited for the model.

24 Pavón-Carrasco, F. J., Osete, M. L., Torta, J. M., and De Santis, A. (2014). A geomagnetic field model for the Holocene based on archaeomagnetic and lava flow data. *Earth and Planetary Science Letters* 388, 98–109. The paper of the model SHA.DIF.14k; not read. Its coefficients, every 50 years to 1900, are in a RAR archive at EarthRef ERDA 1897, with no licence stated, so we give only our derived numbers.

25 GFZ Helmholtz Centre for Geosciences. CALSxk models: GFZ's own copy of CALS10k.2 and its dipole-moment series (DM_CALS10k_2.zip, August 2016), used as checks.

26 IAGA Working Group V-MOD (2024). International Geomagnetic Reference Field, 14th generation: Gauss coefficients 1900–2025. NOAA National Centers for Environmental Information. Used for g_1^0 in 2025 (−29,350.0 nT) and in 1990 (−29,775 nT).

27 SpaceWeatherNews (S0), "internal GrokBot Team 007" (undated). SPACE WEATHER NEWS & RESEARCH PUBLICATIONS 2026, S0 News's research note 007, a Google Doc read on November 9, 2026. Not peer reviewed; no licence. Checked in full on our page on the South Atlantic Anomaly.

28 Schanner, M., Bohsung, L., Fischer, C., Korte, M., and Holschneider, M. (2023). The global geomagnetic field over the historical era: what can we learn from ship-log declinations? *Earth, Planets and Space* 75, 96. CC BY 4.0. Full text; the model HistKalmag is served through a request form, which we did not submit.

METHOD

How this was checked

On November 9, 2026, we checked every statement, number, quotation and citation on this page against its source. We read the paper in full, in the copy of the publisher's PDF that one of its authors posts, with its Crossref and PubMed records; its 2008 re-analysis by one of the authors in full; ten later papers, chapters and a thesis in full or in the sections cited, three papers in their abstracts or significance statement and one in an index copy of its abstract; the gufm1 paper in full, supplied by the site's owner from JSTOR; and the field models' papers, descriptions and files, about 30 items in all. The report is quoted from tactiq.io's automatic transcript, supplied by the site's owner; we did not see its graphics. Suttie and colleagues (2011) is paywalled and unread, and its publisher's site, like *Science*'s, showed our tools a challenge page that we did not try to pass.

The verdicts and the items tagged "Our analysis" are our own assessment, built on the cited sources. They include the weakening rates of the axial dipole and the dipole moment in eight open field models, the decade-by-decade fall since 1840, what the 1590 field and the loss since then depend on, the split of the dipole's change by hemisphere and by normal and reversed flux at the core's surface, and London's and Cape Town's compass, the dipole's tilt and the dip pole in gufm1.

We downloaded the models' public files and computed every number ourselves: first with numpy, under rules written before each analysis, then with the standard-library script this page hosts, which gives the same numbers. Our code reproduces GFZ's own dipole series for CALS10k.2 to within 0.006 ×10²² A m², COV-OBS.x2's own table to within 0.1 nT and g_1^0 in 1990 to within 5 nT of the reference value, and it reproduces the paper's split of the fall by hemisphere. Some pre-registered readings failed as worded: gufm1's fall before 1840 averages 15.2 nT a year, not exactly the prescribed 15, and isn't a straight line at the tolerance we set; and reversed flux in the south carried at least half of the 1840–1990 fall in only one of our four runs. We could not repeat the 2006 method on today's archaeointensity database, GEOMAGIA50, whose query page could not reach its data and whose data come only through a form; its rules are hosted, marked not run. Two newer models, BIGMUDIh.1 and HistKalmag, were out of reach, so we take BIGMUDIh.1 from its abstract, and HistKalmag's paper gives no rate before 1840.

Before publication, a separate fresh review re-ran every number with its own code and re-checked the quotations, sources and verdicts. After it we rated the paper's claim that reversed flux in the south drove the fall True rather than Partly true, resting it on the later literature instead of our own count of the share, which depends on how it is made; restated the grounds for Overstated and Misread; gave the 2008 re-analysis's judgment that no change is most probable; added the pre-1840 slope pinned at 1840, as the paper fits it, and the reversed-flux shares counted several ways; put the dipole-moment rates on each model's 1840 value, as our rules said; charted SHA.DIF.14k; and read the gufm1 paper in full.

This page was researched and written with Claude, an AI assistant made by Anthropic, and then re-checked against its sources in a separate verification pass.

The verdicts on this page

MISLEADING	Contains something true but leaves a false impression, usually by leaving out key context.
OVERSTATED	Has some basis but claims much more than the evidence supports.
MISREAD	Cites a real source but gets wrong what it says.
UNCONFIRMED	Rests on a preliminary result that hasn't been confirmed.
TRUE	The evidence supports the claim.

All ten verdicts, and how we check

CORRECTIONS

Corrections and changes

If we get something wrong, we fix it and record the change below with the date. If a correction changes a verdict, the log says what the old verdict was.

Change log

Nov 9, 2026	Published on factchecked.science after a full check against the sources. Built from our verification of Gubbins, Jones and Finlay (2006) and of S0's special report of November 9, 2026: five claims rated on the site's scale, two the paper's own and three the report's. The chart and tables are our own analysis of public field models; no figure from the paper is redrawn.

Fact-Checked Science is independent. It isn't affiliated with the channels, presenters or authors whose claims it checks.

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