

NON-MARINE TETRAPOD EXTINCTIONS SOLVE EXTINCTION PERIODICITY MYSTERY

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Based on their compiled data set of ten extinction episodes (four of which had no known extinction rates), Rampino et al. (2020) claimed a 27.5-My period in non-marine-tetrapod extinctions. I reassessed that claim using the Gauss–Vaníček spectral analysis (GVSA), which revealed spectra of extremely low fidelity (mostly $\ll 1$) dominated by the Earth’s axial precession, without 99%-significant periods, but with hundreds of 95%-significant periods unrelated to the extinctions and the claimed period. Therefore, the data are physically nonsensical as far as any underlining cyclicality is concerned. The analysis did not reveal the claimed period in any band, at either 99% or 95% significance, so the claimed period is a ghost due to intermediary astronomical forcing of highly gapped data sampled arbitrarily and processed with inapt techniques. Thanks to the GVSA’s absolute accuracy, and insensitivity of non-marine data to the ocean-tidal component, I present remarkable proof that very long periods such as ~ 9 My (~ 27 My), ~ 11 My (~ 22 My), and ~ 33 My (~ 66 My), previously claimed in extinction data sets, have a common astronomical origin. They primarily arise due to the Earth’s axial precession, enforcing of which then is a must in paleostudies.

Keywords: non-marine tetrapod extinctions; periodicity; spectral analyses of extinction episodes

Introduction

Based on data they had compiled from selected sources, Rampino et al. (2020) claimed a $P = 27.5$ My periodicity in non-marine tetrapod extinctions. Their compiled data set consisted of ten extinction episodes spanning 290 My or just about one galactic year; see Table 1, *ibid.* The authors have sampled their data highly arbitrarily so that 40% of the data had unknown or undeclared extinction rates. At the same time, they have included only extinction pulses with $\sim 10\%$ + loss of tetrapod families in the data set. To examine the data set for periodicity, *ibid.* have used the Fourier’s and circular spectral analysis (CSA) methods.

Here reassessed are the ten non-marine extinction events from Table 1 of *ibid.*, which the lead author has confirmed and also furnished the data set that *ibid.* had spectrally analyzed — but which contained 88 values along a gapped time scale (M.R. Rampino, personal communication, 22 December 2020 – 8 January 2021). The lead author then retracted that data set, claiming that he had sent it by mistake, but then failed to provide the allegedly actual data set that they had spectrally analyzed in support of their 2020 claim of the 27.5-My period in ten non-marine extinctions. Thus, their claimed period could be due to a blunder.

Methodology

The previous claim of the same period but from crater impacting, made by Rampino and Caldeira (2015) using the CSA, has been disputed based on adverse effects that clustering produces in the CSA as applied to gapped records of natural data sets, by Meier and Holm–Alwmark (2017). Furthermore, Rampino and Caldeira (2015) had declared their worldview in which they deem 13 values insufficient for spectral analyses (“...using *Fourier analysis on only 13 crater ages, found a 28.4 Myr peak...*”), but then went on to analyze and declare the same peak from even fewer values in their 2020 study.

Since Rampino et al. (2020) had also attached a physical meaning to their claimed period, I here analyze the raw compiled data only and thus stay as close as possible to the physics implications of my result, if any. This approach means that I do not apply any pre-processing of data or post-processing to enhance spectra, as done by some. Also, I use a different method for spectral analysis to examine the spectra at both 99%- and 95%-significance levels.

Specifically, to verify the claimed 27.5 My period, I use the Gauss–Vaníček method of spectral analysis (GVSA) by Vaníček (1969, 1971). The GVSA belongs to the least-squares class of spectral analysis techniques, has many advantages over the Fourier class of spectral analysis techniques in analyzing sparse natural data of long spans (Pre-

ss et al., 2007), has proven itself in analyzing gapped extinction records (Omerbashich, 2006), and provides total accuracy in extracting periods from sets of natural data sets — down to the prescribed accuracy of analyzed data themselves (Omerbashich, 2007; 2019a; 2019b). The minimum number of values that the GVSA can estimate spectra from is 3.

For easier understanding, an extinction percentage rate on each of the ten non-marine extinctions has been uniformly expressed — here in terms of a fictitious 1000-sample survivals bin so that, for example, a 20% genera extinction rate is represented by the number 800 (of “survivals”). Undeclared extinction levels were taken at the median rate and thus represented by the number 500, which is an arbitrary choice here used to illustrate the inaptness of the data, so it does not matter whether this choice is 10, 25, 50, 75, or anything else because no one knows what those extinction levels are in reality so that any guess is equally unreliable. Namely, this study concludes by showing that the six remaining values with declared extinction rates are at least as reliable when taken alone (revealing familiar very long periodicities previously claimed in paleostudies) as when expanded by the four said events with undeclared extinction rates. Note here that the GVSA produces the same results whether one uses percentages or sample bins consistently.

Results and Discussion

Allowing for relatively high 50%-extinction rates on all four events that lacked a declared extinction level (end-of-Jurassic, mid-of-Norian, end-of-Carnian, and end-of-Guadalupi-

an), the only 99%-significant periods found in the full band (0.02–145 My) were imprints of astronomical cycles unrelated to extinctions, Table 1.

Period P_i [years]	Fidelity	Magnitude [var%]	Notes
863,640	$1.3 \cdot 10^{-3}$	89.98	precession modulation (vanishes after enforcing precession)
24,450	$1.1 \cdot 10^{-6}$	92.87	Earth's precession of $\sim 26,000$ yr, as reflected in the data
21,230	$8.0 \cdot 10^{-7}$	90.74	precession split (vanishes after enforcing precession)

Table 1. The 99%-significant periods in the 0.02–145 My full band, from the Gauss–Vaniček spectral analysis (GVSA) of the Rampino et al. (2020) compiled ten non-marine extinction events spanning one galactic year (here 250 My). Survival rates on 4 of 10 extinction events of unknown or undeclared extinction rates fixed at 50%.

Enforcing (removing) the Earth's axial precession period, Table 1, from the raw (unweighted, no preprocessing, no zero-padding) survival data in the full band returned no 99%-significant periodicity. There were 95%-significant peaks, the longest 3.88935-My at 90.02 var% and statistical fidelity of weak 0.027 — where usually 12 or more characterizes a physical process (Omerbashich, 2006), so those peaks are physically nonsensical. Enforcing both the precession and modular 863.4-ky periods resulted in no 99%-significant periods and an improved albeit still physically meaningless spectrum with eight well-resolved periods significant at the 95%-confidence level — the longest being 0.29327-My at 95.78 var% and a statistical fidelity of 0.00015. The vanishing of the 0.86-My period after enforcing the 24,450-yr period alone, or both of them, has revealed that the former period is astronomical as well. The physically nonsensical high rate of 95%-significant periods reflects an overall deficiency of the here reassessed data set.

The same enforcing but in the 5–50 My narrowed band used by Rampino et al. (2020) has also resulted in no 99%-significant peaks. The spectrum somewhat improved, albeit still containing 16 physically nonsensical, well-resolved periods above the 95% confidence level, with the longest one of 33.55 My at 81.63 var% and fidelity of only 0.02. This period has missed the claimed period (which Rampino et al. (2020) assigned 99% confidence to) by a significantly distinguishing 22%. Finally, enforcing both the precession and 863.4 ky periods has again resulted in no 99%-significant periods. The spectrum itself featured eight well-resolved periods at the 95%-significance level, once again rendering the spectrum physically nonsensical. Here, the 9.31903-My period at a high 98.34 var% was the longest. However, a low fidelity, here of 0.15 (which at the same time is the highest found on any period detected in this study), characterizes this period also.

This analysis did not reveal the claimed period in any band at any level of significance. On the contrary, the longest period detected after enforcing the astronomical cycles, which also happens to be the (insignificantly) closest peak to the extinctions episodes, was only 9.32 My long. This period could represent a $T/3$ base cycle — whose full presumed phase, of $T = 27.96$ My, is then off from the claimed period by just 1.7%. In either case, the claimed period is a ghost, i.e., unreal (physically meaningless). It is one of many noise imprints due to intermediary astronomical forcing and deficiencies in processing techniques and approaches like sampling arbitrariness, and as such, it cannot be attributed to any physical phenomena directly.

When extinction events are assigned weights according to the reliability declared in Table 1 of Rampino et al. (2020), the GVSA returns over 250 significant periods in a 1000-lines spectrum, further highlighting the physically nonsensical nature of the examined data set.

It is puzzling why *ibid.* decided to include the alleged extinction levels (with undeclared or unknown extinction levels) as such a highly arbitrary intervention on practically half of their data set leaves their result open to interpretation. Indeed, excluding the four extinction events without associated extinction levels from the analysis has resulted in the GVSA spectra (of the remaining six non-marine extinction events over the full band) without 99%-significant peaks. There are 14 peaks at the 95% significance, again dominated by the Earth's axial precession, and where 0.86364-My at 99.31 var% with a pale 0.0013 fidelity is the longest. After enforcing the precession period, all 95%-significant spectral peaks vanished, meaning the data set is dominated strongly by the astronomical periodicity. Life on Earth does not die out every precession cycle, so none of the periods that are modulations of each other and the precession (so that they vanish with enforcing the

precession period) can be physically real either. Instead, all of the periods found are imprints of astronomical periodicity in some intermediary data. In turn, the precession period's fidelity serves as a statistical gauge for this study so that any other periods whose statistical fidelity remains within an order of magnitude from the precession period's fidelity can be deemed physically irrelevant also.

Finally, GVSA spectra in the narrow band (5–50 My) from the six events with known extinction rates also contain no 99%-significant peaks. At the same time, nine spectral peaks were at the 95%-confidence level; see Figure 1. However, they have also vanished after enforcing the Earth's axial precession. Importantly, the longest of those nine periods were 33.84146-My at 97.31 var%, with a moderate fidelity of 2.0, 11.93548-My at 95.76 var%, with a low 0.25 fidelity, and 9.63542-My at 97.79 var%, with a low 0.16 fidelity. The complete vanishing of these three periods after enforcing the precession is one of the most remarkable proofs yet that such very long periods in extinction records are of intermediary astronomical origin; see Table 2.

As it turns out, see Table 2, the Earth's precession is the main culprit behind the ~9 My (~27 My), ~11 My (~22 My), and ~33 My (~66 My), and their variant ranges that appear in the literature periodically (sic). Thanks to its remarkable accuracy and precision, the GVSA of the non-marine extinction events was able to decipher these commonly reported periods as mutually precisely (mathematically) related modulations of each other, thereby exposing such periods as a physical system of adynamical astronomical reflections onto intermediary data. For example, looking at the nine periods from Table 2, the 33.84146-My period is just the 8.48624-My period quadrupled, or 6.67870-My quintupled, while the 11.93548-My period is simply the 7.95129-My period tripled-halved. Even if the data span had exceeded two galactic years, rendering galactic-scale physical pheno-

mena plausible extinction-level events, such events still could not be ascribed to an individual galactic event. Namely, periods most previously claimed in the literature are just multiples of some other periods that appear as periods in extinctions and other records of paleodata.

Once again then, not only that an independent verification could not corroborate the claimed period, but adding the four alleged extinction events to the data has proven itself as detrimental to the overall spectral accuracy, while at the same time obscuring the astronomical dominance as identified to astonishing accuracy from the six most reliable extinction events alone.

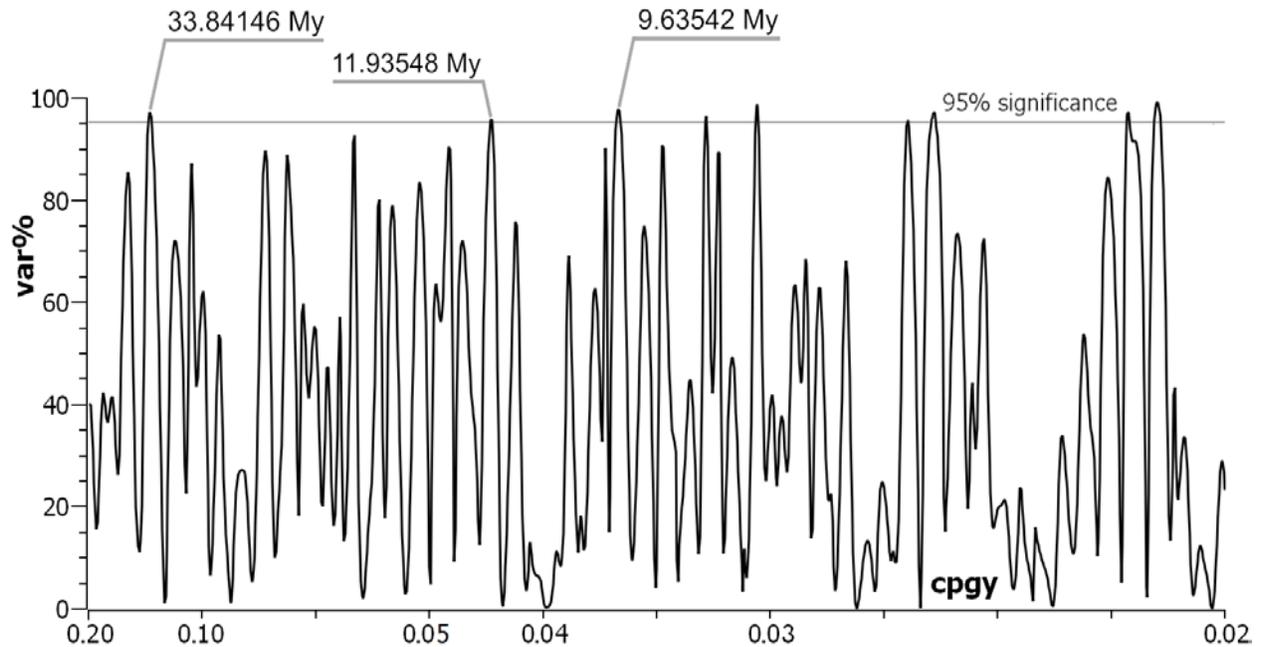


Figure 1. GVSA spectrum of non-marine extinctions over the last galactic year (here 250 My), in var%, the 5–50 My band. Frequencies are in cycles per galactic year (cpgy). The nine 95%-significant periods are in Table 2. After enforcing the Earth's axial precession period, all significant periods vanish.

Period P_j [My]	Fidelity	Magnitude [var%]	Notes
33.84146	2.00	97.31	reported in literature also as 61-68 My and 120-140 My
11.93548	0.25	95.76	reported in literature also as 20-25 My
9.63542	0.16	97.79	reported in literature also as 27-33 My and here as 9.32 My
8.48624	0.13	96.49	1/4 of P_1 ; reported in literature also as 24-26 My
7.95129	0.11	98.77	2/3 of P_2 ; reported in literature also as 19-23 My
6.67870	0.08	95.68	1/5 of P_1
6.49883	0.07	96.50	2.5% split from P_6
5.41463	0.05	97.32	4/25 of P_1
5.28069	0.05	99.14	2.5% split from P_8

Table 2. 95%-significant periods in the 5-50 My band, from the GVSA of the Rampino et al. (2020) compiled six non-marine extinction events spanning barely one galactic year, where all six events are of known extinction (survival) rates. All nine periods, previously reported in the literature as the proof of galactic causes of periodic mass extinctions, vanish upon enforcing the Earth's axial precession, Table 1, demonstrating that all are illusory periods without direct physical meaning. Non-marine extinction events are particularly suitable for this type of analysis due to their insensitivity to the ocean-tidal component as the most dominant systematic background content of the signal in paleodata records. Thanks to the absolute accuracy and internal precision of the GVSA, non-marine data for the first time reveal the complete story behind the commonly reported very long (on the order of My) periods in paleodata, exposing all such periods as mutually precisely (mathematically) related, and therefore just a reflection of astronomical forcing in intermediary data. Note here that insufficient data coverage (span) is the primary reason why the GVSA of the six non-marine extinction events in the full band did not reveal periods longer than 0.86364-My.

Conclusions

The non-marine extinctions data, here reassessed using the Gauss–Vaniček spectral analysis (GVSA), were found to be of extremely low time-resolution (heavily gapped), arbitrarily compiled, of unworkable correlations along with overall trivial statistical fidelity, and containing no systematically discernable physical meaning other than astronomical forcing commonly seen affecting intermediaries of paleodata sampled. Consequently, the GVSA, as a technique impervious to data sparseness, was able to extract overburdened spectra only, rendering the examined data useless for paleostudies. Additionally, since the data span barely exceeded one galactic year, galactic-scale phenomena could not be

invoked as a cause of periodic extinctions; data should span at least two galactic years before such phenomena could become credible.

Very long periodicity in paleodata, previously claimed in the literature, such as ~9 My (~27 My), ~11 My (~22 My), ~33 My (~66 My), and their variations are modulations of the Earth's axial precession primarily. Therefore, the Earth's precession period(s) must be enforced in spectral analyses of paleodata as a standard procedure to make the said periodicities vanish before making any conclusions on physical phenomena causing periodic mass extinctions.

References

- Meier, M.M.M., Holm–Alwmark, S. (2017) A tale of clusters: no resolvable periodicity in the terrestrial impact cratering record. *Mon. Not. R. Astron. Soc.* 467(3):2545–2551. DOI: <https://doi.org/10.1093/mnras/stx211>
- Omerbashich, M. (2006). Gauss–Vaniček Spectral Analysis of the Sepkoski Compendium: No New Life Cycles. *Comp. Sci. Eng.* 8(4):26-30. DOI: <https://doi.org/10.1109/MCSE.2006.68>
- Omerbashich, M. (2007) Erratum due to journal error *Comp. Sci. Eng.* 9(4):5-6. DOI: <https://doi.org/10.1109/MCSE.2007.79>
- Omerbashich, M. (2007). Magnification of mantle resonance as a cause of tectonics. *Geodyn. Acta* 20(6):369-383. DOI: <https://doi.org/10.3166/ga.20.369-383>
- Omerbashich, M. (2019a) Earth body resonance. *J. Geophys.* 63:15-29. ARK: <https://n2t.net/ark:/88439/x020219>
- Omerbashich, M. (2019b) Moon body resonance. *J. Geophys.* 63:30-42. ARK: <https://n2t.net/ark:/88439/x034508>
- Press, W.H., Teukolsky, S.A., Vetterling, W.T., Flannery, B.P. (2007). *Numerical Recipes: The Art of Scientific Computing* (3rd Ed.). Cambridge University Press. ISBN 9780521880688
- Rampino, M.R., Caldeira, K. (2015) Periodic impact cratering and extinction events over the last 260 million years. *Mon. Not. R. Astron. Soc.* 454(4):3480-3484. DOI: <https://doi.org/10.1093/mnras/stv2088>
- Rampino, M.R., Caldeira, K., Zhu, Y. (2020) A 27.5-My underlying periodicity detected in extinction episodes of non-marine tetrapods, *Historical Biology*. DOI: <https://doi.org/10.1080/08912963.2020.1849178>
- Vaniček, P. (1969). Approximate spectral analysis by least-squares fit. *Astrophysics and Space Science* 4(4):387–391. DOI: <https://doi.org/10.1007/BF00651344>
- Vaniček, P. (1971). Further development and properties of the spectral analysis by least-squares fit. *Astrophysics and Space Science* 12(1):10–33. DOI: <https://doi.org/10.1007/BF00656134>