Unified Cycle Theory: Introduction & Data

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This paper introduces a sequence of cycles found in nature. Dubbed the Extra-Universal Wave Series (EUWS), these cycles may originate from outside of our observable universe. Collectively, the cycles were first discovered in 2008 and published in *The Unified Cycle Theory* in 2009. However, many of these cycles were already discovered on an individual basis prior to 2008. Examples include the ~ 516-yr climate cycle determined from ocean sediments, the ~ 1547-yr Dansgaard-Oeschger climate cycle, the ~ 4640-yr Bond climate cycle, the ~ 125-kyr climate cycle, the ~ 30-myr extinction cycle, and Earth's ~ 822-myr cycle in crustal formation. *The Unified Cycle Theory* provided a breakthrough by linking these cycles as part of an infinite harmonic sequence. Unlikely as it may seem, individual wavelengths in this sequence are precisely separated from adjacent cycles by a factor of three. Linkage implies these cycles share a common source. Whether the EUWS frequency is as short as 9.57 days or as long as 22.2 billion years, the source of these fluctuations must be the same. Heretofore, geologists have concentrated on processes internal to Earth's ecosystem to explain volcanic episodes, when, in fact, oscillations in star formation rates suggest these cycles were already shaping our universe prior to Earth's existence. A single equation describes the EUWS oscillations. This paper presents the equation, provides graphics of theoretical oscillations, and demonstrates the occurrences of these cycles in nature. The presence of EUWS cycles can be detected in a wide variety of ways including star formation oscillations, episodes of volcanism, global climate fluctuations, evolution of new gene families, mass extinction cycles, spots in the Sun and stars, civilization cycles, and financial panic cycles.

1. Introduction

Numerous cycles exist in nature. Climate cycles approximately equal to 516-yr [1], 1547-yr [2], 4640-yr [3], and 125-kyr [4] are widely studied. Biologists, geologists, and physicists have studied a 30-myr mass-extinction cycle for nearly 30 years. [5] And geologists first noticed an approximately 822-myr cycle in crustal formation 20 years ago. [6] In addition, Milankovitch cycles influence global climate – contributing heavily to ice-ages. [7] Milankovitch cycles occur because of Earth's eccentricity, obliquity, and precession. In addition, various solar and geomagnetic cycles may affect short-term climatic conditions. And finally, historical and financial data reveals rhythmic patterns in civilizations and markets. [8], [45], [46], [54]

After stripping away the effects from the known Milankovitch, solar, and geomagnetic oscillations, a mysterious set of cycles remain visible on Earth – as well as in the universe. For reasons to be discussed later, this sequence of cycles was labeled the Extra-Universal Wave Series (EUWS). [8] The periods for these mysterious cycles come in pulses separated precisely by a factor of three. Evidence comes in the form of cycles in volcanism, global climate, evolution, mass-extinctions, and even mass human behavior.

It can be inferred that EUWS cycles belong to an infinitely long sequence. In this sequence, wavelengths can be detected ranging from as small as 9.57 days to as long as 22.2 billion years. And no logical reason exists to expect this uninterrupted sequence to abruptly cease at any particular wavelength beyond these endpoints.

To encourage understanding, modeling, and testing, equations were developed to approximate the EUWS oscillations. The definitions section of this paper provides a general equation. From the general equation, individual EUWS components can be constructed for modeling purposes.

Finally, this paper examines the evidence. A total of 31 time-series were located that contain EUWS, Milankovitch, solar, geomagnetic, biological, and human-behavior cycles. The data came from a variety of sciences and researchers. A close analysis of the correlations provides important clues about cause and effect. Based on this analysis, it appears that a complex chain of events controls Earth's ecosystem. These chain reactions produce a myriad of correlated cycles that appear in the histories reviewed in this paper.

2. Definitions, Abbreviations, & Acronyms

Timescales:

- Ga – billion years ago
- Ma – million years ago
- Ka – thousand years ago
- tyr – trillion year
- gyr – billion year
- myr- million year
- kyr – thousand year
- yr – year

Extra-Universal – An oxymoron used to clearly differentiate between the observable universe and the portion that resides beyond mankind's current observational capabilities.

EUWS cycles – Extra-Universal Wave Series cycles are traceable back to the time of our universal event horizon. Because the wavelength of the largest detectable cycle equals 22.2-gyr, these cycles are assumed to possess an extra-universal origin. The EUWS cycles provide strong evidence of constant fluctuations in the universe, which occur as a sequence of cycles with wavelengths occurring in precise multiples of three.

EUWS equation – At any moment in time, the composite amplitude for all EUWS cycles equals the sum of the individual amplitudes from the infinite cycles in the sequence. Verified and hypothetical cycles in the range from 1.06 days to 16.2 trillion years are listed in Table 1. At any moment in time, the power of a EUWS cycle, y_i, is defined by the following equation:

$$y_i = d_n * \sin\left(\frac{2\pi\left(t_i + t_{scale}\right)}{\lambda_n} + \theta_n\right)$$

n Designates the nth EUWS cycle, where n = 0, 1, 2, … 33. The shortest hypothetical cycle equals ~ 1.06-day (λ_0) while the longest hypothetical cycle equals ~ 16.2-tyr (λ_{33}).

d_n The density factor for the n^{th} EUWS cycle. Values for d_n have not been determined; however, based on preliminary studies, the density of any EUWS cycle ~ 1-to-2 times the density of the adjacent higher-frequency cycle. For example, a density factor of 1.5 for d_{n+1}/d_n serves as a good ratio for constructing a composite model of several adjacent EUWS cycles.

λ_n The n^{th} EUWS wavelength. The subscript n indicates the power associated with the period. For example, $\lambda_6 = 3^6\lambda_0$ ~ 2.12-yr. Table 1 provides estimated wavelengths for λ_n.

θ_n Indicates the phase of each cycle, λ_n. Table 1 provides estimated values for θ_n.

t_i A point in time when the force of λ_n is estimated.

t_{scale} The time-scale adjustment. For the Gregorian calendar, the adjustment equals -2000 years. For the AP/BP timescale, where 1950 is defined as present, the adjustment equals -50 years. And for the AP/BP timescale where 2000 equals the present, the adjustment is 0 years.

For example, to construct a model for the 822-myr EUWS cycle (n = 24), set the model to:

$$y_i = \sin\left(\left(2\pi t_i / 821.993055939681\right) + 3.620205630\right)$$

The EUWS wavelengths listed in Table 1 are estimated to be accurate to within 1% of the true periods. This error was determined from a series of tests that showed the statistical significance of these cycles deteriorated by adjusting the theoretical wavelengths by more than 1% from current estimates.

Even though the accuracy resides within 1% of the listed periods, Table 1 carries the precision for λ_n and θ_n to between 10 and 15 digits. At first glance, this degree of precision seems ridiculous; however, it's required to keep the EUWS cycles in sync when multiple cycles are combined into one model. Keeping the cycles in sync becomes especially difficult when combining 5 or more EUWS cycles. The issue of keeping the oscillations in sync becomes serious when the highest frequency wavelength covers thousands of cycles. The precision provided in Table 1 eliminates potential synchronization issues in most cases.

n	λ_n (abbrv.)	λ_n (Full Wavelength)	θ_n (Phase)
		Year Timescale	
0	1.06-day	0.00291043587785295	0.457368659
1	3.19-day	0.00873130763355885	5.388443996
2	9.57-day	0.0261939229006765	0.748950468
3	28.7-day	0.0785817687020297	3.391242830
4	86.1-day	0.235745306106089	0.083216746
5	258-day	0.707235918318267	5.263726692
		Year Timescale	
6	2.12-yr	2.12170775495480	0.707378034
7	6.37-yr	6.36512326486440	1.282990250
8	19.1-yr	19.0953697945932	5.663651193
9	57.3-yr	57.2861093837796	0.840686201
10	172-yr	171.858328151339	3.421821408
11	516-yr	515.574984454017	2.187804708
		Kyr Timescale	
12	1.55-kyr	1.54672495336205	1.776465808
13	4.64-kyr	4.64017486008615	5.828143046
14	13.9-kyr	13.9205245802584	2.989911921
15	41.8-kyr	41.7615737407753	2.043834879
16	125-kyr	125.284721222326	1.728475865
17	376-kyr	375.854163666978	3.717751296
		Myr Timescale	
18	1.13-myr	1.12756249100093	0.192052902
19	3.38-myr	3.38268747300280	3.205610299
20	10.1-myr	10.1480624190084	4.210129444
21	30.4-myr	30.4441872570252	0.356178951
22	91.3-myr	91.3325617710757	1.165923889
23	274-myr	273.997685313227	1.435838868
24	822-myr	821.993055939681	3.620205630
		Gyr Timescale	
25	2.47-gyr	2.46597916781904	2.253932782
26	7.40-gyr	7.39793750345713	3.892903602
27	22.2-gyr	22.1938125103714	2.344832106
28	66.6-gyr	66.5814375311142	6.017598479
29	200-gyr	199.744312593342	5.147458834
30	599-gyr	599.232937780027	4.857412286
		Tyr Timescale	
31	1.80-tyr	1.79769881334008	4.760730103
32	5.39-tyr	5.39309644002025	4.728502700
33	16.2-tyr	16.1792893200607	4.717760244

Table 1. Equation Parameters for EUWS Cycles

3. Linkage and Correlation

A leading expert on the Precambrian eon, Kent Condie, hinted at the cyclical nature of volcanism when he wrote about a possible Snowball Earth episode more than two billion years ago: "Analysis of the global distribution of U/Pb ages of both subduction-related granitoids and of detrital zircons suggests that a widespread reduction in magmatic activity on Earth beginning about 2.45 Ga and lasting for 200–250 Myr... Also during this time, there are major unconformities on most cratons... Oxygenation of the atmosphere at 2.4 Ga followed by widespread glaciation at 2.4–2.3 Ga also may be related to the initiation of the global magmatic lull. We suggest that an episodic mantle thermal regime, during which a large part of the plate circuit effectively stagnates, may explain the 250-Myr magmatic age gap on Earth and a remarkable feature of the Paleoproterozoic record." [9]

The idea that geological activity occurs at regular intervals is sometimes met with great skepticism. When asked to comment about Condie's hypothesis of periodicity, UCLA geologist Mark

Harrison stated his intrigue; however, he said it would be hard to demonstrate a smoking gun. Harrison warned that the 2.5-2.3 Ga lull could merely be an illusion that arose because volcanic material from that period was not well preserved. [10]

Especially in geology and climatology, obvious cyclical behavior is often explained in terms of random fluctuations, measurement noise, or inadequate sampling. Yet, in spite of potential bias against a cyclical explanation, the facts speak for themselves. A substantial set of evidence shows that naturally occurring cycles constantly shape our universe and planet. In fact, these cyclical patterns are detectable for all timescales, and they are hypothesized to span infinite frequencies. [8]

Years ago, Brand Blandshard stated, “Science has advanced in the past precisely because, when things happened whose causes were unknown, it was assumed that they had causes nevertheless.” [11] This paper begins the process of scientific advancement by showing that previously unexplained fluctuations result from a harmonic sequence of cycles found in nature. These cycles are hypothesized to possess an extra-universal origin. Hence, they are named the Extra-Universal Wave Series (EUWS). While fully recognizing the risk of such a theory, evidence appears strong enough to warrant this assessment. Even if testing eventually rejects the hypothesis of an extra-universal origin, these cycles certainly possess an extra-terrestrial origin. This is especially important for geologists, because untold hours have been wasted on searching for earthbound explanations for the cycles found in geological formations.

More than 25 years ago, University of Chicago paleontologists David Raup and Jack Sepkoski hypothesized a 26-myr cycle in mass extinctions. In a paper, the pair suggested that the extinction cycle resulted from an unknown extra-terrestrial origin: “If periodicity of extinctions in the geologic past can be demonstrated, the implications are broad and fundamental… If the forcing agent is in the physical environment, does this reflect an earthbound process or something in space? If the latter, are the extra-terrestrial influences solar, solar system, or galactic? Although none of these alternatives can be ruled out now, we favor extra-terrestrial causes for the reason that purely biological or earthbound physical cycles seem incredible, where the cycles are of fixed length and measured on a time scale of tens of millions of years. By contrast, astronomical and astrophysical cycles of this order are plausible even though candidates for the particular cycle observed in the extinction data are few.” [12]

By 1998, researchers increasingly noticed periodicity in other processes that roughly matched the mass-extinction cycle. These observations led a pair of geophysicists from India, R.K. Tiwari and K.N. Rao, to hypothesize the following: "Earth's history has been witness to recurrently alternating phases of catastrophic evolution and dominant tectonic deformations, contractions and extension of rifting and spreading leading to quasi-cyclic changes in sedimentary environment and various earth processes. Recent studies have shown quasi-periodicities of 32 ±2 myr in various … processes indicating a remarkable kinship… We argue here for a common physical link among the periodic global CO_2 variations, mantle convection, geomagnetic reversals, volcanism, geotectonic cycles, and enhanced cometary showers.” [13]

Tiwari & Rao then presented a model of a chain of galactic, Solar System, and geophysical interactions that ended in mass-extinctions. Their model essentially entailed 6 levels in the chain, as outlined below:

1. The Sun’s motion interacts with interstellar clouds.
2. The interaction disrupts cometary orbits, resulting in asteroid impacts on Earth and the other planets.
3. Asteroid impacts influence tectonic change, sea floor spreading, and disturbances in deep Earth processes.
4. Because of the increased geological activity, changes occur in sea levels, geochemical anomalies, weathering, volcanic activity, and geomagnetic reversals.
5. Next, CO_2 levels vary, reflecting changes in climate.
6. Finally, mass extinctions result from the atmospheric and climatic changes. [13]

Both Raup & Sepkoski and Tiwari & Rao came close to getting it right. The source of these cycles is undoubtedly extra-terrestrial, and a close link exists between earthbound processes and extra-terrestrial events. However, three oversights prevented these cycle-pioneers from pinpointing the EUWS source hypothesized in this paper:

- Rather than a galactic origin, these cycles originate from outside of our observable universe.
- Instead of asteroids causing geological changes, the EUWS cycles cause both asteroid impacts and major geological events to occur simultaneously – thus producing correlations that give an illusion of cause and effect.
- The correlations and interactions aren’t limited to cycles in the 30-myr range. Similar correlated relationships are observable in cycles as short as 9.57 days and as long as 22.2 billion years.

4. Evidence

Universal **Event Horizon** – As a result of the 5-Year Wilkinson Microwave Anisotropy Probe (WMAP1), during 2008 a team of NASA scientists claimed support for the Big Bang Theory and estimated the Big Bang occurred at 13.73 ±0.12 Ga. [14] Figure 1 includes a model of several hypothetical EUWS cycle (red line) along with detrended fluctuations in galaxy star formation rates (blue line). [15]

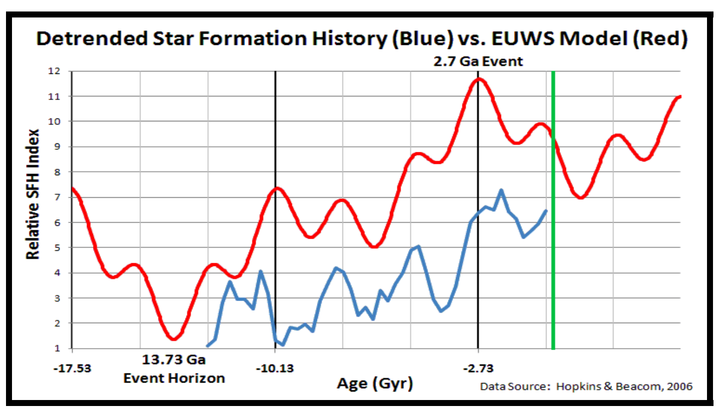

Fig. 1. Galaxy Star Formation History

Episodes in star formation (blue line) from Hopkins & Beacom [15] closely coincide with peaks and troughs of the 2.47-gyr and 7.40-gyr EUWS cycles in Figure 1. However, the technology for estimating star formation ages remains somewhat inaccurate.

Age-errors often approach or exceed 10%. And age-errors that large prevent spectral analyses with a high level of confidence. Hence, a meaningful study must wait until star formation dating improves. Nonetheless, based on the best current estimate, galaxy star formation patterns do mimic EUWS cycles.

The evidence becomes more certain at the hypothesized 22.2-gyr peak at 2.73 Ga. This theoretical peak behaved as a virtual direct-hit for the 2.7 Ga Event on Earth. Within a few million years of 2.7 Ga, a rare supercontinent formed. [16], [17] And this supercontinent formed at the same time as the greatest volcanic episode in Earth's 4.54-gyr history. [16], [17] The volcanism at this time was so extreme that it prompted geologist Kent Condie to present a paper entitled *What on Earth Happened 2.7 Billion Years Ago?* [17]

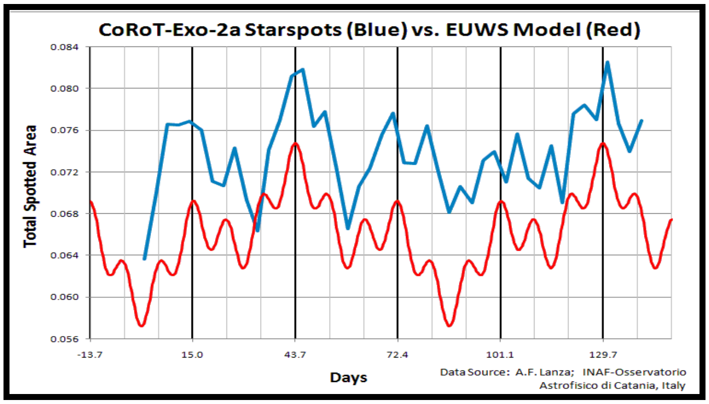

Fig. 2. Starspots in CoRoT-Exo-2a

Sun & Stars – All stars appear to possess a unique and dominant period in spot activity. For example, the Sun displays its 11-year Schwabe cycle. In addition to this dominant cycle, EUWS cycles can be detected at 516-yr from reconstructed sunspots derived from tree-ring analysis [18], [19], daily sunspot numbers [20], and starspots on CoRoT-Exo-2a. [21] Figure 2 shows the close link between spots on the star CoRoT-Exo-2a and an EUWS model constructed from 86.1-day, 28.7-day, and 9.56-day cycles.

Geomagnetic Activity – An unusual correlation appeared between the 41.8-kyr EUWS cycle and Earth's magnetic field, derived from ocean sediments. [22] Figure 3 generally shows a strong correlation at exactly twice the 41.8-kyr period.

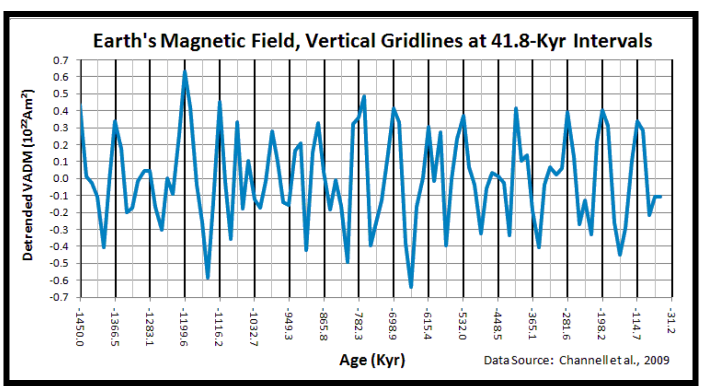

Fig. 3. Geomagnetism

This exceptional correlation (at double the expected value) may indicate that EUWS cycles possess polarity. This could be similar to the 22-year polarity period associated with the 11-year sunspot cycle. If so, this polarity only reveals itself in geomagnetism, and the EUWS cycles generally appear at ½ the geomagnetic periods for all other interactions with nature.

Volcanic Activity – The strongest link between hypothesized EUWS cycles and natural events occurs with volcanic activity. In Figure 4, the vertical gridlines represent theoretical peaks of the 822-myr EUWS cycle. The red line represents an EUWS model constructed from the 22.2-gyr, 7.40-gyr, 2.47-gyr, and 822-myr cycles. Notice the close correlation between the model and the history of Earth's crustal formation (green line) [6] and a histogram of zircon ages reflecting cycles in volcanic activity (blue line). [23]

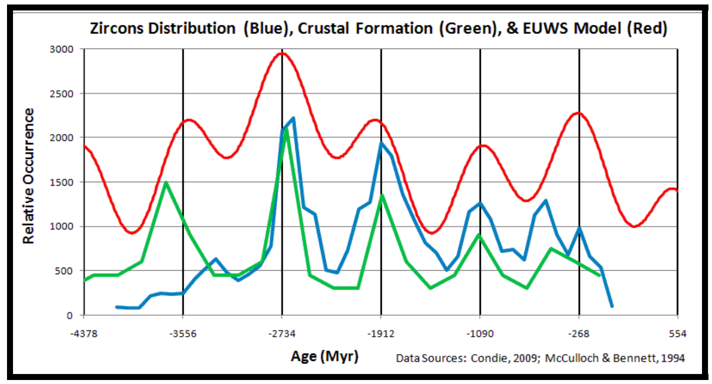

Fig. 4. Volcanic Activity

The 822-myr EUWS cycle is also associated with super-continent formation and super-continent breakup. [17], [28] In addition, higher frequency EUWS cycles are found in Condie's zircon data for periods of 274-myr, 91.3-myr, and 30.4-myr. [23]

Zooming in much further, EUWS cycles of 41.8-kyr, 13.9-kyr, 4.64-kyr, and 1.55-kyr closely correspond to oscillations in volcanic activity derived from volcanic aerosol [24], [25] and volcanic dust from the Vostok ice-core. [26], [27]

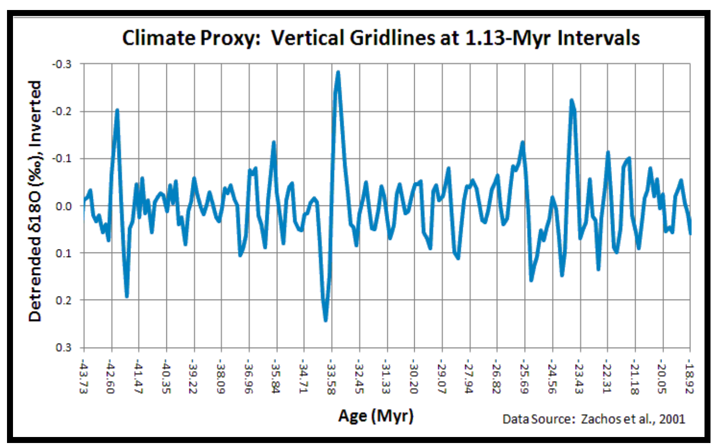

Fig. 5. Global Climate

Global Climate – Milankovitch cycles interfere with detection of the EUWS cycles in the range between 400-kyr and 20-kyr. However, a 274-myr cycle appears in a climate proxy derived from fossils and minerals. [29] Furthermore, EUWS cycles of 30.4-myr, 10.1-myr, 3.38-myr, 1.13-myr, and 125-kyr are all detectable in a climate time-series constructed from ocean sediments. [30] Figure 5 shows the 1.13-myr cycle in global climate compiled by paleo-oceanographer James Zachos. [30]

For periods below the 23.7-kyr precession cycle, EUWS cycles of 13.9-kyr, 4.64-kyr, and 1.55-kyr are detectable to varying degrees in climate proxies scattered around the globe. These climate proxies come from Dome Fuji in Antarctica [31], [32], Sofular Cave in Turkey [33], [34], a Greenland ice-core [35], [36], and Soreq and Peqiin Caves in Israel. [37], [38]

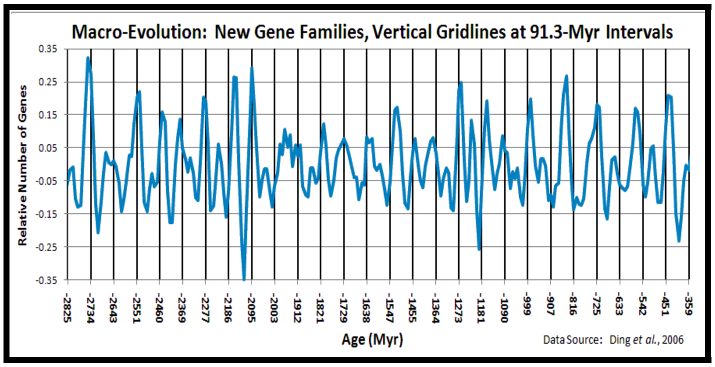

Fig. 6. Macro-Evolution

Evolution – With dramatic episodes in volcanism and climate affecting Earth's ecosystem, it should come as no surprise that the EUWS cycles also correlate closely with changes in the rate of macro-evolution and the occurrence of mass-extinctions. Figure 6 shows an exceptionally strong correlation between the 91.3-myr EUWS cycle and the appearance of new genes. [39]

Even though the 91.3-myr cycle appears with great strength, caution must be used with the genetic time-series constructed by Ding *et al*. [39] The biologists failed to provide error estimates along with their age determinations. That's important because spectral analysis requires ages to be accurate within 5% of their true ages for optimal testing.

An independent analysis, using cross-correlations with zircon ages [23] and ages of eukaryotic and stromatolite abundance [41], [42], [43], [44] reveals that Ding's data contains sufficient accuracy beyond 2.7 Ga. However, neither Guohui Ding nor genetic-statistics expert Ziheng Yang ventured a guess at the age-errors for the data from Ding *et al*. Yang now prefers a newer Bayesian method. [40] Unfortunately, because of its newness, biologists have yet to use Yang's Bayesian approach for estimating genetic ages. Hopefully, biologists will soon begin using Yang's method to provide a more accurate genetic time-series. Until then, the time-series by Ding *et al*. is the only known genetic record covering Earth's entire 4.5-gyr history.

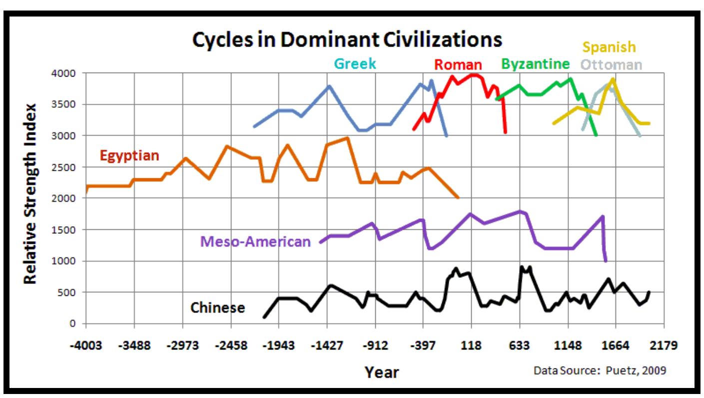

Fig. 7. Dominant Civilizations

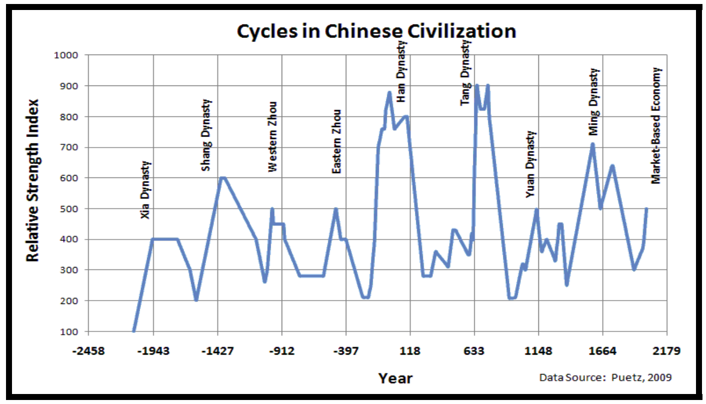

Fig. 8. Chinese Civilization

Mass Human Behavior – In addition to biological effects related to evolution, EUWS cycles also influence human behavior. Data from Solanki *et al*. shows a 516-yr cycle in sunspots. [18], [19] In addition, Stuiver *et al*. found a ~ 516-yr cycle in climate. [1] Amazingly, the 516-yr cycle also appears in an index reflecting the rise and fall of dominant civilizations. [8] Figure 7 depicts 516-yr cycles in Greek, Roman, Byzantine, Ottoman, Spanish, Egyptian, Chinese, and Meso-American civilizations.

Figure 8 reveals the 40-century history of the 516-yr cycle in Chinese civilization. Dynasties other than the ones listed in the graph also existed; however, the ones in Figure 8 were the only dynasties that unified China during relatively peaceful periods. Dynasties not listed in Figure 8 involved periods when China spilt into factions or was involved in civil wars.

The 19.1-yr EUWS cycle appears in commodity prices from ancient Babylonia. [45] The first portion of the Babylonian time-series was recorded nearly 2400 years ago. Then next oldest price index involves rice prices in China for the past 1000 years. [54] The Chinese rice index correlates closely with the 172-year EUWS cycle.

The 19.1-year EUWS cycle also appears in recurring financial panics covering the 200+ year history of the United States. Figure 9 shows a detrended stock market time-series with theoretical 19.1-year peaks marked by the vertical gridlines. [46], [47], [48], [49], [50], [51], [52], [53]

Major stock market declines in Figure 9 correspond to the aftermath of the 1797-1800 recession, the Panic of 1835, the Panic of 1854, the Panic of 1873, the depression of 1892-96, the bear market of 1910-21, the Crash of 1929, the bear market of 1969-82, the Crash of 1987, and the Sub-prime Crisis of 2007-08.

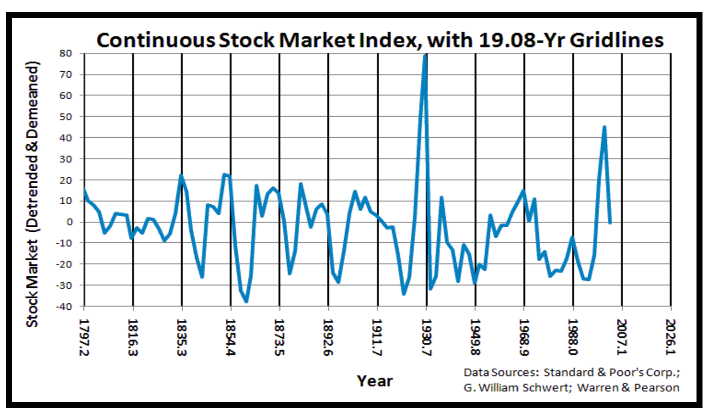

Fig. 9. Financial Panic Cycle

5. Discussion

Four factors exist that interfere with detecting a cyclical pattern in a time-series. (1) If the ages in the series are not known exactly, the estimated ages must be reasonably accurate for the analysis to be meaningful. (2) Detection of a cyclical pattern can be hampered if other non-cyclical factors influence the signal substantially more than the cycle. (3) Detection of a cyclical pattern can be obscured by another more dominant cycle from a completely different course. (4) Various forms of sampling bias can create a time-series that misrepresents the nature of the true population.

For every time-series presented in this paper, some of the four inhibiting factors listed above were at play to varying degrees. Hence, valid criticism can be lobbied against some aspects of some of the data. Nonetheless, marginal data does not imply worthless data. Marginal data can be analyzed. And if the analysis shows positive results, then efforts need to be directed toward finding improved data. Once improved data is obtained, more definitive analyses then become possible.

However, several datasets were found where the four inhibiting factors listed above were minimal. By stepping back and looking at the big picture, it seems highly unlikely that the EUWS cycles, observed in such a wide variety of data, could have accidentally and independently appeared as a harmonic sequence.

Finally, and perhaps more importantly, the EUWS cycles appear in harmonics of three. Additionally, actual peaks from historical data closely match theoretical peaks (sometimes with a lag in climatic data). In combination, these correlations strongly point to a single conclusion – that these cycles are linked by a common physical source.

6. Conclusion

Individual parameters for the EUWS equation are listed in Table 1. These estimates are accurate to within 1% of the listed wavelength. These equations and parameters provide researchers with a means for constructing models for testing purposes.

This paper also provided graphic evidence in the form of raw time-series plots. The data shows strong synchronization between the peaks of parent and child EUWS cycles. Establishing a link among the EUWS cycles provides an important first step in determining a cause.

In order to confirm potential cause-and-effect relationships, lengthy, well-dated datasets must be obtained for analysis. At this point, much of the data strongly supports the hypothesis of a harmonic link among the EUWS cycles. At the same time, other datasets suggest a link, but they lack the statistical characteristics to conclusively establish a link.

The strongest data supporting the EUWS cycles comes from all types of volcanic indices. EUWS cycles are detectable in volcanism ranging from 1.55-kyr up to 822-myr. This is the area where future research should concentrate the heaviest. In addition, the EUWS cycles also strongly appear in global climate oscillations, but only for periods above and below the Milankovitch range of 20-kyr to 500-kyr. Climate cycles generally follow volcanic episodes. This implies that EUWS cycles produce volcanic cycles, which in turn causes climate change.

With varying degrees of certainty, other evidence exists in the form of starspots, star formation, asteroid impacts, evolution, mass-extinctions, human behavior, and atmospheric composition. Firmly establishing these events in the same chain as EUWS cycles and volcanism will take time. Nonetheless, whatever causes the 9.56-day EUWS cycle must be the same as the physical entity that causes the 22.2 billion year EUWS cycle.

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