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Issue 117 of *Infinite Energy* includes a reprint of Dr. James Maxlow's Natural Philosophy Alliance paper, "Global Expansion Tectonics: A Significant Challenge for Physics." We are providing the original NPA paper for our readers so that they will be able to look at the color versions of all of the figures. *Infinite Energy* publishes in black and white and, therefore, the color from the figures is lost.

Global Expansion Tectonics: A Significant Challenge for Physics

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A very important geophysical contribution to appreciating modern tectonic theory has been the completion of seafloor magnetic mapping, plus radiometric and paleontological age dating of seafloor crusts beneath all Earth's oceans. This seafloor mapping places finite spatial and temporal constraints on the crustal plate motion history within all of the ocean basins, back to the Early Jurassic Period (approximately 170 million years ago). The magnetic patterns and age dating determined during this seafloor mapping program were historically interpreted as evidence for seafloor growth and spreading, which led to the promotion of Plate Tectonic theory during the 1960s – a theory that adopts and continues to insist on the fundamental premise that Earth radius remains constant with time. In contrast, by removing this premise and allowing Earth radius to vary with time, this same seafloor mapping provides us with a unique opportunity to accurately measure past Earth radius, to both latitudinally and longitudinally constrain plate assemblages on smaller radius Earth models, and to quantify a rate of increase in crustal surface area, and hence radius throughout Earth history; giving rise to the alternative tectonic theory called Global Expansion Tectonics. Mathematical modeling of this seafloor mapping shows that Earth radius is increasing exponentially through time, and radius is currently increasing at a rate of 22 millimetres per year. While this seafloor mapping quantifies Global Expansion Tectonics as a viable alternative to conventional tectonic theory, a fundamental challenge is presented to physics, whereby an explanation is required to explain how and where additional matter is generated and accumulated within the Earth in order to comply with the increase in Earth radius, as evidenced from empirical seafloor crustal data.

1. Introduction

2.1. Conventional Plate Tectonic theory

Plate Tectonics today is considered the main tectonic theory in Earth Sciences. Tectonics (from the Late Latin tectonicus, from the Greek: τεκτονικός "*pertaining to building*") is a scientific term that describes the large scale motions of the Earth's crust.

In conventional Plate Tectonic theory the Earth's crust is broken up into a series seven or eight major and many minor plates, made up of both continental and oceanic crusts (Figure 1). These crustal plates move in relation to one another at one of three types of plate boundaries: convergent or collisional boundaries, where plates are said to collide resulting in the formation of mountains; divergent boundaries, where ocean crusts break apart and new volcanic crust is erupted along spreading centres; and conservative or transform boundaries, where plates are faulted relative to each other. Earthquakes, volcanic activity, mountain-building, and oceanic trench formation are said to occur along each of these plate boundaries with movement of the plates typically varying from 0 to 100 millimetres annually.

The tectonic plates are composed of two types of crust: thick continental crusts and thin oceanic crusts. One of the main points the theory proposes is that an equal amount of surface area of the plates must disappear into the mantle along the convergent boundaries by a process referred to as "subduction", more or less in equilibrium with the new oceanic crust that is formed along the divergent margins by seafloor spreading. This is also referred to as the "conveyor belt principle". In this way, it is assumed, but never acknowledged as a basic premise, that the total surface area of the Earth remains constant and hence the radius of the Earth also remains constant throughout time.

Fig. 1. Map of the Earth showing distribution of tectonic plates comprising continental and oceanic crustal rocks.

Although subduction is believed by plate tectonists to be the strongest force driving plate motions, it is acknowledged by many researchers that it cannot be the only force since there are plates, such as the North American Plate, that are moving, yet are nowhere being subducted. The same is true for the enormous Eurasian Plate, and especially for the Antarctican Plate. So, even though Plate Tectonics is currently considered the main tectonic theory in Earth Sciences, the sources and mechanism for plate motion are still a matter of intensive research and discussion among many Earth scientists.

2.2. Alternative Theory

Somewhat like the way Alfred Wegner's original arguments for Continental Drift were initially heckled and rejected during the early 20th century, the concept of an Earth increasing its radius also continues to this day to be unfairly rejected, based on very similar, rather emotive argument. In all fairness though, during the pre-1960s global data gathering was simply not present or not extensive enough for early researchers into Earth expansion to argue their case with "*sound geological evidence*".

Since then a vast amount of new global geological, geophysical, and geographical data has been gathered and studied. While routinely used in Plate Tectonic studies, this data has never been seriously looked at other than from a constant, static radius Earth perspective. More importantly, this new data has never been applied to the alternative theories, such as Earth Expansion, which unfortunately leaves science without an acceptable alternative geological viewpoint or basis for correct scientific argument.

The suggestion that continents have not always been at their present positions was introduced as early as 1596 by the Dutch map maker Abraham Ortelius. Ortelius suggested, based on the symmetric outlines of the Atlantic coastlines, that the Americas, Eurasia and Africa were once joined and have since drifted apart "*by earthquakes and floods*", creating the modern Atlantic Ocean. For evidence he wrote: "*The vestiges of the rupture reveal themselves, if someone brings forward a map of the world and considers carefully the coasts of the three continents.*"

In 1915 Alfred Wegener also noted how the east coast of South America and the west coast of Africa looked as if they were once attached, and he went further to suggest that the present continents once formed a single Pangaean land mass - the ancient supercontinent called Pangaea, that subsequently broke up and drifted apart.

So, did Wegener get it all wrong? No, he didn't get it wrong, in fact he is justifiably credited for being one of the first scientists to apply correct geological observation to support and substantiate his claims. But, what he and others subsequently didn't do was to go far enough. What he and others have since failed to recognize is that, as well as fitting the South American and African coastlines together to give a reasonably good fit-together, the remaining Indian, Pacific and Southern Ocean coastlines can just as easily be fitted together, with similar fossil and geological evidence to support these observations.

It is interesting to note that in 1958 Professor Sam Warren Carey [1] made comment that this trans-Atlantic fit was, however, not as good as Wegener and others had claimed. In researching the concept of Continental Drift, Carey made a scale model of the Earth and demonstrated "*if all the continents were reassembled into a Pangaean configuration on a model representing the Earths modern dimensions, the fit was reasonably precise at the centre of the reassembly and along the common margins of north-west Africa and the United States east coast embayment, but became progressively imperfect away from these areas*". Carey concluded from this research that the fit of these ancient continents "*could be made much more precise in these areas if the diameter of the Earth was smaller at the time of Pangaea*". Unfortunately, with the subsequent promotion of Plate Tectonics, these basic physical observations and conclusions of Carey continue to be neglected and totally ignored to this day.

During the 20th century there were also a number of other independent thinkers who considered opening of the oceans could be attributed to an increase in Earth radius. Roberto Mantovani in 1889, and again in 1909, published a theory of "*earth expansion and continental drift*" [2]. In this theory he considered that a closed continent covered the entire surface on a smaller Earth. He suggested that "*thermal expansion led to volcanic activity, which broke the land mass into smaller continents*". These continents then drifted away from each other because of further expansion at the "*rip-zones*", where the oceans currently lie. This was followed by the pioneering work and publications of Lindemann in 1927 [3], small Earth modeling by Ott Christoph Hilgenberg during the 1930s [4], Professor Sam Warren Carey during the 1950s to late 1990s, Jan Koziar during the 1980s, and small Earth modeling by Klaus Vogel during the 1980s and 1990s.

These, and other model makers at the time all showed that if each of the continents were physically fitted together they would neatly envelope the Earth with continental crust on a small Earth globe some 50 to 55% of its present size. This coincidence led Hilgenberg [4] and Vogel [5], and similarly Carey [1] from his early Continental Drift studies, as well as Koziar [6] from his extensive mathematical and crustal modeling, to conclude "*terrestrial expansion brought about the splitting and gradual dispersal of continents as they moved radially outwards during geological time*".

Throughout subsequent literature, small Earth models, and hence Earth expansion, continue to be judged by the scientific community to be speculative and inconclusive. It is considered that one of the main reasons for this judgment is because, with early reconstruction based primarily on a visual fit-together of opposing continental margins, the small Earth models often gave rise to a wide variation of crustal fits, in particular for the Pacific Ocean region. Similarly, a conclusive, quantifiable "*motor and mechanism*" for Earth expansion was not able to be given.

The small Earth models of Hilgenberg and Vogel in particular indicate, however, that an ancient Pangaean crustal assemblage on a small Earth globe, representing between 55% to 60% of the present Earth radius, can produce a tight, coherent fit of all continents, remnant mountain belts from the various continents match consistently, geological boundaries are maintained, and ancient biological boundaries match precisely.

2.3. An Important Contribution to Tectonic Theory

In 1947, a team of scientists led by Maurice Ewing, utilizing the Woods Hole Oceanographic Institution's research vessel Atlantis, confirmed the existence of a rise in the level of the seafloor in the central Atlantic Ocean, now known as the mid-ocean-ridge. They also found that the seafloor beneath the thin layer of sediments consisted of basalt, not granite as previously assumed, which is one of the main constituents of the continental rocks. They also found the seafloor crustal rocks to be much thinner than continental crust. All of these new findings raised important and intriguing questions about the way we perceive seafloor crust. The most important of which was that the ocean is not simply "oceanised" or drowned continental crust covered by sea water, as previously thought.

Beginning in the 1950s, scientists, using magnetic instruments (magnetometers) adapted from airborne devices developed during World War II to detect submarines, also began to recognize strange magnetic patterns across the seafloor. This finding, though unexpected, was not entirely surprising because it is known that basalt - the iron-rich volcanic rock making up the seafloor, contains a strongly magnetic mineral called magnetite, which can locally distort compass readings. More importantly, because the presence of magnetite gives the basalt measurable magnetic properties, these newly discovered magnetic seafloor patterns provided an important means to study the distribution of volcanic rocks throughout each of the ocean floors.

As more and more of the seafloor was mapped during the 1950s, these magnetic patterns turned out not to be random or isolated occurrences, but instead revealed recognizable zebra-like stripes, found to be symmetrical about the mid-ocean-ridges (Figure 2). Alternating stripes of basaltic rock were shown to be laid out in parallel rows on either side of the mid-ocean-ridge, one stripe with normal polarity and the adjoining stripe with reversed polarity. The overall pattern, as defined by these alternating bands of normally and reversely polarized rock became known as *"magnetic striping"*.

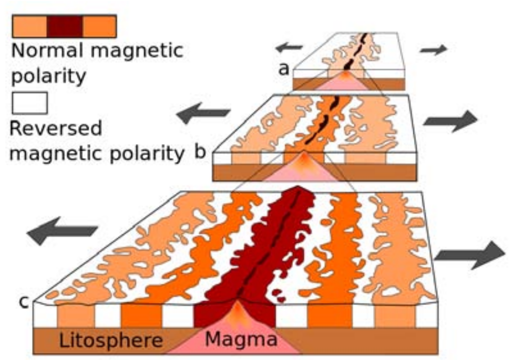

Fig. 2. Symmetrical magnetic stripping across part of the Atlantic Ocean mid-ocean-ridge.

The discovery of this symmetrical magnetic striping pattern suggested a close relationship between the mid-ocean-ridges and the formation of the stripes. In 1961, scientists - most notably the American geologist Harry Hess, began to theorize that the mid-ocean-ridges mark structurally weak zones, where the ocean floor was being "ripped apart" lengthwise along the mid-ocean-ridge crest. From this it was suggested that new volcanic magma from deep within the Earth must rise through these weak zones and eventually erupt along the crest of the ridges to create new seafloor crust. This process, later called seafloor spreading, operates over many millions of years and continues to form new seafloor along the entire 60,000km-long system of mid-ocean-ridges now known to be present in each of the oceans.

This hypothesis was supported by several lines of evidence. At or near the crest of the mid-ocean-ridges the rocks are very young, and these become progressively older away from the ridge crest. The youngest rocks at the ridge crest always have present-day normal polarity. Stripes of rock parallel to the ridge crest were then shown to have alternated in magnetic polarity from normal to reverse to normal, etc, suggesting the Earth's magnetic field has reversed many times throughout its history.

By explaining both the zebra-like magnetic striping and the construction of the mid-ocean-ridge system, the seafloor spreading hypothesis quickly gained converts. Furthermore, the seafloor crust now came to be universally appreciated as a natural "tape recording" of the history of the reversals in the Earth's magnetic field.

A profound consequence of this observation of seafloor spreading is that new crust was, and is now still being continually created along the oceanic ridges. This observation was initially considered to support the theory of Earth Expansion, whereby new crust was formed at the mid-ocean-ridges as a consequence of an increase in Earth radius, however history shows that subsequent work favoured the Plate Tectonic theory, whereby excess crust was postulated to "disappear" along seafloor trenches, where so-called "subduction" occurs.

2.4. Bedrock Geological Map of the World

Subsequent work by the Commission for the Geological Map of the World and UNESCO [7] during the 1980s led to the publication of the "Bedrock Geological Map of the World" in 1990 (Figure 3, and legend shown in Figure 4). In this global geological map, the magnetic striping shown in Figure 2 was taken a step further. By dating the ages of the seafloor crust at regular intervals throughout each of the oceans, and comparing these ages with the magnetic striping, the seafloor crust was then mapped according to the ages of the rocks.

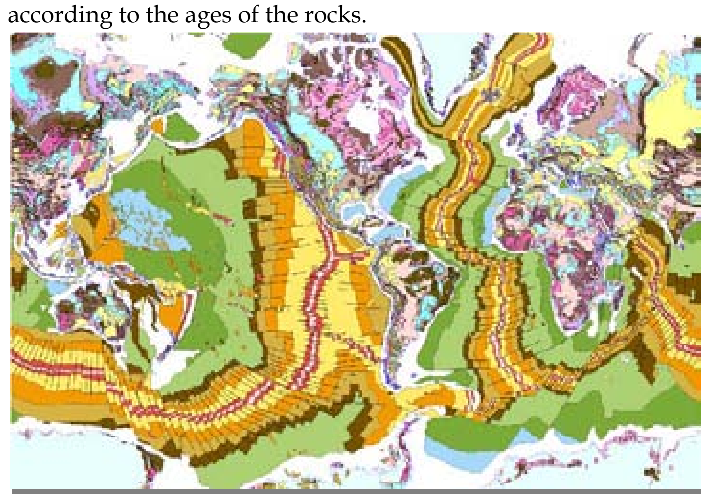

Fig. 3. Bedrock Geological Map of the World (digitized with permission from the Commission for the Geological Map of the World and UNESCO, 1990 [7]).

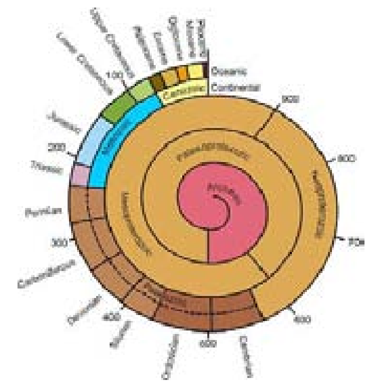

Fig. 4. Geological time scale showing the various continental and seafloor ages in millions of years before the present. The beginning of the Archaean Eon is about 4,000 million years ago.

At this stage in our introduction there are a number of very important considerations about the bedrock geological mapping shown in Figure 3 that must be fully appreciated. As noted, this seafloor mapping is a natural "*tape recording*" of the history of the reversals in the Earth's magnetic field, and similarly represents a factual distribution of the volcanic rocks that make up the seafloor crusts. This preserved history must therefore be strictly adhered to during any theoretical modeling, or assemblage of the various crustal plates and continents back in time.

It should also be appreciated that none, or very little of this magnetic striping and age dating evidence was available when both Plate Tectonic and Expansion Tectonic theories were first proposed. The global distribution of magnetic striping and age dating was, in fact, completed later in order to quantify the assemblages of the various plates and continents on a Plate Tectonic Earth model.

The important considerations include:

- Firstly, the pattern of colours of the crustal rocks shown in Figure 3 confirms that the seafloor crustal rocks are vastly different from the continental crustal rocks. Similarly, many of the continental crustal rocks, in general, are more ancient than the seafloor crustal rocks.
- Secondly, the striping shown in Figure 3 confirms that all of the oceans contain a mid-ocean-ridge and each ocean is increasing its surface area away from the mid-ocean-ridges with time. It can be seen that this increase in surface area is symmetrical about the mid-ocean-ridges in each ocean, and the maximum age of exposed seafloor volcanic crust, located along the continental margins, is Early Jurassic – about 170 million years old.
- Thirdly, if it were possible to move back in time, each of the stripes shown in Figure 3 must be progressively removed. The corresponding edges of each coloured stripe must then be moved closer together as we move back in time – that is, the erupted volcanic rocks within each stripe must be returned to the mantle where they originally came from.
- Fourthly, as we move back in time, each of the continents must move closer together in strict accordance with the striping evidence, regardless of which tectonic theory is adhered to. This phenomenon can then be used to constrain the location of the various crustal plates when modeling the location of the ancient continents and oceans back in time.
- Fifthly, by measuring the surface areas of each stripe in turn this information can be used to investigate the potential change in Earth surface area with time, and from this investigate the potential variance in Earth radius with time.

2.5. Tectonic Comparisons

In Plate Tectonic theory, the radius of the Earth remains essentially constant with time. As new volcanic rock intrudes along the mid-ocean-ridge spreading centres, the seafloor widens allowing new seafloor crust to form. To maintain a theoretical constant radius Earth, an equal amount of pre-existing seafloor or continental crust must then be disposed of elsewhere and returned to the mantle by a theorized process called *"subduction"*. This subduction process forms the basis for Plate Tectonic theory, and consequentially is essential for maintaining a static radius Earth premise. While this process appears simple and logical, and of course almost universally accepted, it does not always honor the geological evidence preserved in rocks from adjoining continents.

Alternatively, for an Expansion Tectonic Earth, the very same volcanic rock injected along the mid-ocean-ridge spreading centres again widen the oceans and adds to the surface area of seafloor crust. For an Expansion Tectonic Earth, this increase in surface area of all seafloors is a result of an increase in Earth radius, and there is therefore no requirement for any net disposal of excess crust by subduction processes, nor is there a need to consider pre-existing crusts.

What this means is, for an Expansion Tectonic Earth, prior to about 200 million years ago the modern oceans did not exist. At that time, all continental crust was united to form a single supercontinent called Pangaea, enclosing the entire ancient Earth on a smaller radius Earth. Instead of the modern oceans, a network of relatively shallow seas then covered low-lying parts of the Pangaean supercontinent. At that time all of the relatively young seafloor volcanic crust, as well as much of the ocean water and atmosphere were retained within the mantle, where they originated from. Similarly, crustal modeling studies demonstrate that all data from each of the adjoining continental crusts support and quantify an increasing Earth radius process.

While arguments exist for and against both tectonic theories, it is emphasized that model makers have demonstrated that the crustal fragments and supporting geological evidence making up both the ancient supercontinents and modern continents can indeed be fitted together precisely, somewhat like a spherical jigsaw, on a smaller radius Earth to form a single supercontinent. The question that must therefore be asked is, is this empirical phenomenon fact, or mere coincidence?

2. Measuring Earth Radius

If I were to ask what the radius of the Earth was at say one million years in the past, most, if not all people should say they do not know. In reality, most people would probably err towards saying that the ancient Earth radius was the same as it is today. If prompted as to how they know this, I would envisage that many of the answers would range from a guess, to religious indoctrination, through to recitation of the Kant-Laplace theory of the creation of the Solar System, or quotations from the Big Bang theory.

As we all know, *"proof of any theory comes through direct observation or by direct measurement"*. If you cannot physically measure the ancient Earth radius, or provide unequivocal evidence to support conclusions about the ancient Earth radius, then all premises and assumptions regarding a constant Earth radius are mere speculation. In other words, if you cannot conclusively provide evidence to say the ancient Earth radius was, or was not the same as today then current conventional Plate Tectonic theory is potentially incorrect and consideration must therefore be given to alternative theories such as Expansion Tectonics.

2.6. Measuring Ancient Earth Surface Areas

Historically, the determination and quantification of an ancient radius of the Earth has been one of the most basic requirements of any expanding Earth thesis. Prior to completion of the bedrock geological mapping of all oceans during the 1980s, attempts at determining ancient Earth radius were made using empirical modeling studies, as well as from remnant magnetism preserved in rocks, early measurement of areas of seafloor spreading, mantle plume separation and astronomical observation. However, in all cases, because of the limitations in the quality and quantity of data available at the time, it was not possible to accurately determine an ancient Earth radius convincingly enough to sway conventional thinking.

Consideration of available literature suggests that there was also no unified opinion amongst most authors as to whether the Earth may be expanding, contracting, pulsating, rhythmical or static with time. Depending on which method was used to determine the ancient Earth radius, reference is made in the literature of a potential "*large*" expansion of the Earth equated with a rate of increase in Earth radius of between 0.4 to 2 centimetres per year. There are also descriptions of "*gross*" radial expansion reaching several metres per year, and another widely held opinion, which allowed for "*small*" to "*negligible*" radial increase in Earth radius of up to 1 millimetre per year.

Both Jan Koziar in 1980 [6] and Blinov in 1983 [8] were the first to measure seafloor surface areas and they both developed very similar formulae to determine a rate of change in ancient Earth radius. These formulae were based on measurements made on early versions of seafloor crustal mapping, plus estimates of continental surface areas of Phanerozoic (rocks younger than 570 million years) and Precambrian rocks (rocks older than 570 million years).

Now, with the completion of the Bedrock Geological Map of the World [7], it is a relatively easy process to mathematically derive ancient Earth radii using measurements of surface areas of seafloor crusts. We also have the added advantage that these seafloor crusts have known ages to enable us to accurately constrain when the crusts were deposited. Once you know the areas of each of the seafloor crustal stripes, a formula for rate of change in Earth radius can then be determined. This presumes of course that any increase in surface area is confined to the seafloor crusts, which is not strictly correct, but is a reasonable approximation. On an Expansion Tectonic Earth increases in continental crustal areas are primarily a result of crustal stretch, resulting from changing surface curvature through time.

It should, however, be appreciated that the total of the time periods shown by the seafloor mapping in Figure 3 represents only about 4 percent of the total known and age dated Earth history. When we hear mention of any form of Earth expansion it is this limited timeframe that is typically associated with the concept. It is rarely, if ever appreciated that Earth expansion may in fact have also occurred before this period to include the entire history of the Earth.

To measure the surface areas of each of the coloured seafloor stripes in Figure 3 we need to eliminate as much projection distortion from our map as we can, and ideally we need to display the information in spherical format. The method adopted here required the existing Bedrock Geological Map of the World (Figure 3) to be displayed as a 24-gore sinusoidal projection map (Figure 5).

A sinusoidal projection format gives undistorted, true-to-scale geological information from anywhere within the map area, enabling us to both measure and model the data. The term "*gore*" simply means that each curved stripe, representing fifteen degrees of longitude, tapers to zero degrees longitude at each pole, and in Figure 5 I have simply used 24 gores to represent the map data. The uniqueness of this type of map projection is that it can also be cut and pasted directly onto a spherical globe during model construction, as well as forming the basis for detailed small Earth modeling.

Fig. 5. 24-gore sinusoidal map projection of The Bedrock Geological Map of the World. This projection enables the geological map to be displayed in distortion-free spherical format and forms the primary base-map for both surface area measurement and small Earth model reconstructions.

By using this sinusoidal map, each coloured seafloor stripe can be digitized in turn, the surface areas of successive intervals measured, and an ancient Earth radius derived for each time period shown. The raw data from this exercise is summarized in Table 1.

Age Range	Surface Area			Radius
Millions of Years before the Present	Measured Surface Area (x10^7 km^2)	Cummulative Surface Area (x10^7 km^2)	Present Area Minus Ancient Surface Area (x10^7 km^2)	Ancient Earth Radius (km)
0	0	0	51.0000	6370.80
0-1.9	0.5342	0.5342	50.4658	6337.15
1.9-5.9	1.3328	1.8670	49.3300	6265.43
5.9-23.0	4.9213	6.7883	44.2117	5931.49
23.0-37.7	4.1624	10.9507	40.0493	5645.37
37.7-59.2	4.1649	15.1156	35.8844	5343.77
59.2-66.2	1.0462	16.1618	34.8382	5265.30
66.2-84.0	4.7956	20.9574	30.0426	4889.49
84.0-118.7	5.6758	26.6332	24.3668	4403.46
118.7-143.8	1.9348	28.5680	22.4320	4225.02
143.8-205	1.9386	30.5066	20.4934	4038.31

Table 1. Empirical surface areas of each coloured seafloor stripe and derived ancient Earth radius.

2.7. Rate of Increase in Earth Radius

A rate of increase in Earth radius was determined in Maxlow [9] by digitising the areas of post-Triassic seafloor mapping data (Figure 5) and mathematically modeling the resultant cumulative crustal surface areas (Table 1) using formulae developed by Koziar [6] and Blinov [8].

A linear regression analysis of cumulative surface area data demonstrated that the goodness of fit of the data was best described by an exponential increase in surface area with time. From this empirical cumulative surface area data a mathematical expression for post-Triassic exponential increase in Earth radius was derived, and the ancient Earth radii determined, shown plotted in Figure 6.

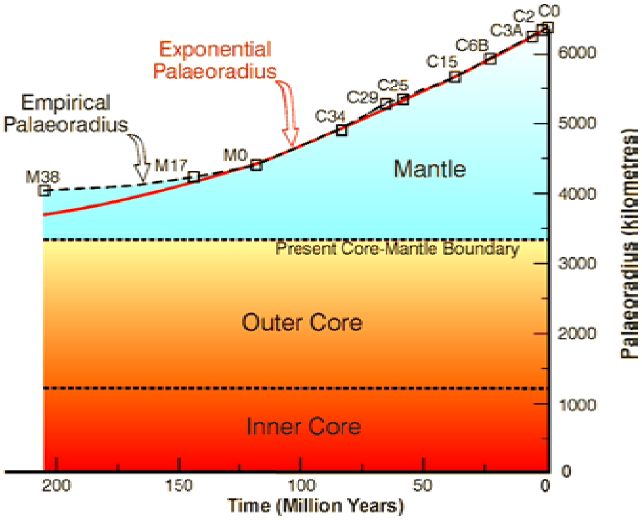

Fig. 6. Ancient radius of the Earth extending from the Triassic to present-day. Radius was calculated from digitized surface areas of post-Triassic seafloor mapping data. Shortfall in measured ancient radius between Chron M17 and M38 represents accumulation of sediments along the continental slopes and shelves.

In contrast to the finite constraint provided by post-Triassic seafloor surface area data, determining a mathematical expression for rate of increase in Earth radius from the Archaean to present-day depends on establishing a Precambrian primordial Earth radius. A number of possible scenarios are summarized in Figure 7, ranging from adoption of the present total continental surface area (Figure 7, Curve A), to an estimate of the total surface area of preserved Archaean crust (Figure 7, Curve D). Studies carried out by Blatt & Jones (1975) [10] to determine the relationship between sedimentary rock age and amount of outcrop area on the present land surface, while speculative, demonstrated a lognormal increase in outcrop area with time. This data is plotted as a cumulative percentage of total continental surface area and, when converted to a radius curve (Figure 7, Curve C), provides a further potential constraint to ancient radius during the Paleozoic and Precambrian times.

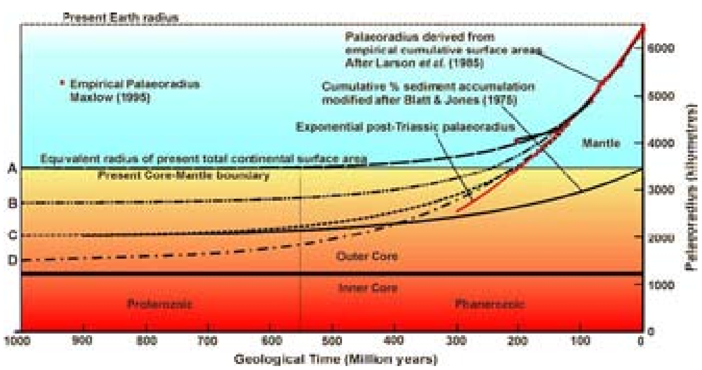

Fig. 7. Constraints to determining a Precambrian primordial Earth radius. Data is shown as time-variant radii for all curves. Curves depict increase in Earth radius constrained by Curve A: the present total continental surface area; Curve B: present total continental surface area less marginal basins; Curve C: cumulative sediment areas (converted to equivalent radii after Blatt & Jones, [10]) and; Curve D: total estimated area of Archaean crust.

While, from a non-geological perspective, Curves A or B (Figure 7) would seem a logical end-point to this discussion and therefore the present-day surface area of existing continental crusts equates to the primordial Earth radius, the geology of the Earth is more complicated than that. As can be seen in Figure 3, continental crusts are made up of a complex array of most ancient crustal fragments, generally surrounded by progressively younger metamorphic and sedimentary rocks. By continuing to move back in time all younger sediments making up the sedimentary rocks, along with all intrusive and extrusive magmatic rocks, must be returned to the ancient lands and mantle respectively, precisely where these rocks came from. By doing so the surface area, and hence radius of the ancient Earth can therefore, in theory, be further reduced in size when moving back in time.

Because of the difficulty in quantifying a primordial Earth radius and estimating the surface areal distributions of present-day Precambrian crusts, reliance was made on constructing spherical models of the post-Triassic Earth using radii determined from the seafloor crustal data (Figure 8). These models effectively quantified Global Expansion Tectonics as a viable tectonic process, and demonstrated that the assemblage of post-Triassic crustal plates gives a better than 99% fit-together for each model constructed and justified continuing the modeling process back to the beginning of the Archaean Eon.

Fig. 8. Spherical models of a post-Triassic Expansion Tectonic Earth. Models demonstrate that seafloor crustal plates assembled on Expansion Tectonic Earth models coincide fully with seafloor spreading and geological data and accord with derived ancient Earth radii.

Pre-Triassic spherical modeling was continued back in time by progressively reducing the ancient Earth radius in incremental stages until each of the remnant Precambrian crustal complexes and basement rocks were assembled. While controversial, this construction method involves progressive removal of all younger continental crust and restoration of basins and rift zones to a pre-extension or pre-rift configuration on a reduced radius earth model (Figure 9).

Unlike the modeling studies of Koziar and Vogel, Precambrian sedimentary basins were also partially removed during modeling to allow for formation of extensional basin settings (e.g. Etheridge et al., [11], for ensialic extension within the Proterozoic basins of northern Australia). This resulted in an Archaean small Earth model comprising remnant Precambrian crustal rocks with an indicated primordial Earth radius of approximately 1700 kilometres. This empirically derived primordial Earth radius therefore represents a potential limiting radius for an Archaean proto-Earth.

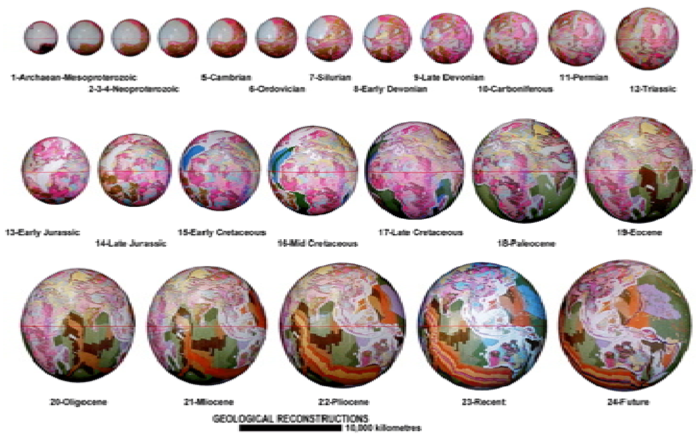

Fig. 9. Spherical Archaean to future Expansion Tectonic Earth geological models. Models show relative increase in Earth radii, showing both continental and oceanic geology. Models range in age from the Archaean to present-day, plus one model projected to 5 million years into the future.

While seemingly incomprehensible, quantification of the methodology and logic behind both the empirical evidence and modeling studies can be found in Maxlow [9]. Reliance is simply made on basic geological evidence preserved in the rock-record. This evidence is empirical data; we are not compromising the geological evidence in any way, only human comprehension. By moving back in time all we are doing is returning eroded sediments back to the ancient land surfaces from where they originate, plus returning intruded and extruded magmatic rocks (plus a proportion of the ocean waters and atmospheric gases) back to the mantle from where they originated from and reducing the Earth radius to accommodate for the reduction in surface area.

A mathematical equation for an exponential rate of increase in Earth radius extending from the Archaean to present-day is then derived by considering the mathematical equation for linear regression:

$$y = Ax + B \qquad \text{Equation 1}$$

Where: y = the Y axis, x = the X axis, A = the gradient of a line, B = the y-intercept of the line.

For a linear increase in palaeoradius this equation is written as:

$$R = At + B \qquad \text{Equation 2}$$

Where: R = Earth radius, t = time before the present (negative).

To determine an exponential increase in radius Equation 2 can be written as:

$$\ln R_a/R_0 = At + B \qquad \text{Equation 3}$$

Where: ln = natural logarithm, R_0 = present Earth radius at time t_0, R_a = ancient Earth radius at time t_a.

Equation 3 simply expresses the exponential curve as a straight line, suitable for analysis using the linear regression Equation 1. Rearranging Equation 3 for radius:

$$Ra = R_0 e^{(At+B)} \qquad \text{Equation 4}$$

Where: e = base of natural logarithm.

Mathematical modeling of a rate of post Triassic Earth expansion in Maxlow demonstrated that the y-intercept B is negligible and can be disregarded. The gradient of the line (A), representing the ancient Earth radius, is a constant k. Equation 4 can then be written as:

$$Ra = R_0 e^{(kt)} \qquad \text{Equation 5}$$

The early Archaean primordial Earth radius R_p, determined from empirical small Earth modeling (Figure 9), is approximately 1700 kilometres. This represents the radius of a primordial Archaean proto-Earth at formation or crustal stabilization of the primitive Earth. It is inferred from empirical post-Triassic surface area studies that changes to Earth radius from the Archaean to present-day increases exponentially. An equation for exponential increase in Earth radius from the Archaean to present-day is then expressed as:

$$R_a = (R_0 - R_p)e^{kt} + R_p \qquad \text{Equation 6}$$

Where: k = 4.5366x10-9/year.

The constant k is determined from Equation 3 by modeling post-Triassic radii derived from empirical seafloor data (Table 1) using 1700 kilometres as the limiting primordial proto-Earth radius to solve for gradient A.

An exponential increase in Earth radius, extending from the Archaean to present-day, calculated from Equation 6, is shown graphically in Figure 10. The ancient radii determined by Koziar [6], based on a 2800 kilometre primordial Earth radius for the Late Precambrian and by Vogel [12], based on a 2850 kilometre primordial Earth radius are also shown for comparison. Both Koziar and Vogel determined a primordial Earth radius by estimating the surface area of preserved Precambrian crust. The locations of Expansion Tectonic Earth models in Maxlow [9] are also shown.

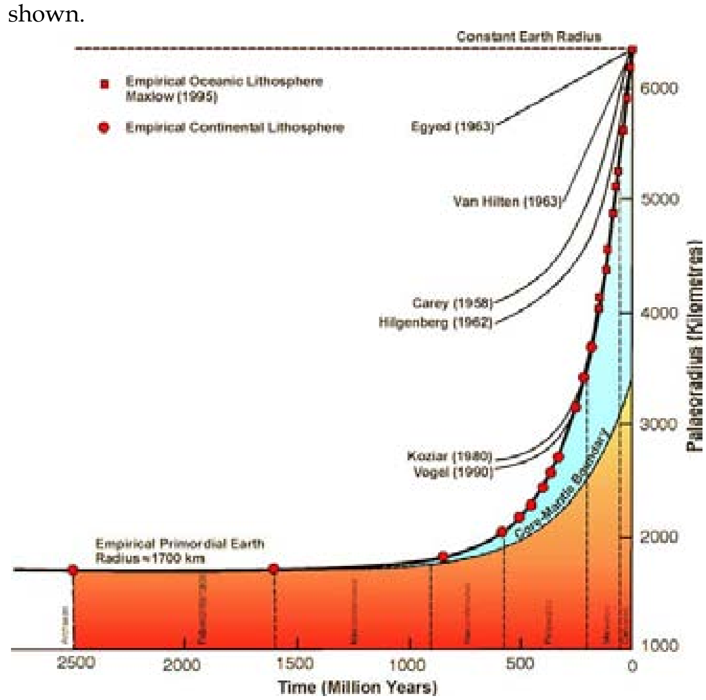

Fig. 10 Exponential increase in Earth radius extending from the Archaean to present-day. Graph shows post-Triassic increase derived from seafloor mapping and pre-Jurassic increase derived from an Archaean primordial Earth radius of 1700 km.

The exponential ancient Earth radius curve (Figure 10) suggests that during the early mid-Precambrian Eons Earth's ancient radius remained relatively static, increasing by approximately 60 kilometres during 3 billion years of Earth history. Since then the Earth has undergone an accelerating increase in radius to the present-day. This increase in both surface area and radius was initially accommodated for in the geological rock-record by crustal extension (stretching). By the late Permian Period (approximately 250 million years ago) the ability for the crustal rocks to extend was then exceeded, resulting in crustal rupture and breakup of the ancient Pangaean supercontinent, giving rise to the modern continents and opening of the modern oceans.

2.8. Kinematics of Earth Expansion

The incremental variations in the physical dimensions of an Earth undergoing an exponential increase in radius with time are qualified further by considering radius, circumference, surface area and volume. Consideration is also given to mass, density and surface gravity under endpoint conditions of constant Earth mass and constant Earth density. At this stage ancient mass, density and surface gravity are indeterminate. Hypothetical variations in mass, density and derived surface gravity are included here to qualify a postulated cause of Earth expansion as proposed by Carey (1983 [13], 1988 [14], 1996) [15].

The physical variation in radius, circumference, surface area and volume of an Earth undergoing an exponential increase in radius from the Archaean to present-day is shown in Figure 11. Each graph shows a 3 billion year history of Precambrian crustal stability, with ancient radius increasing by approximately 60 kilometres, followed by a steady to rapidly accelerating period of increase to the present-day.

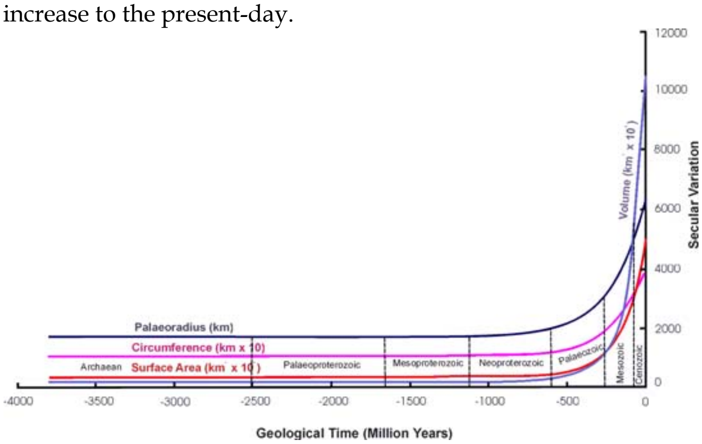

Fig. 11. Physical variation of radius, circumference, surface area and volume. Graphs extend from the Archaean to present-day and are derived using Equation 6.

The present-day annual variations in radius, circumference, surface area and volume are derived using Equation 6. The annual incremental rates are:

Radius	dR/dt_0 = 22 mm/year
Circumference	dC/dt_0 = 140 mm/year
Surface area	dS/dt_0 = 3.5 km^2/year
Volume	dV/dt_0 = 11,000 km^3/year

The incremental rates of Earth expansion determined here compare favorably with estimations derived from published data. For example, Steiner (1977) [16] estimated a global rate of areal seafloor spreading during the past 5 million years of 3.19 km^2/yr. This equates to a calculated rate of radial increase of 20 mm/yr. Also, Garfunkel (1975) [17] calculated an aerial seafloor spreading rate of 3.15 km^2/yr and Parsons (1982) [18] 3.45 km^2/yr, which equate to radial increases of 20 and 23 mm/yr respectively. These figures are substantiated by early space geodetic measurements of intercontinental chord lengths, with a speculative rate of increase in Earth radius calculated by Parkinson (in Carey, 1988) [14] of 24 ± 8 mm/yr and a global mean value calculated by Robaudo & Harrison (1993) [19] of 18 mm/yr.

The rate of equatorial circumferential increase was calculated by Blinov (1983) [8] to be 120 mm/yr by considering relative plate motions in the Pacific, Atlantic and Southern Oceans, giving a rate of radial expansion of 19.1 mm/yr. Using areas of seafloor magnetic data, Steiner (1977) [16] calculated the average seafloor spreading rates for the past 5 million years to be approximately 96 mm/yr for the Pacific Ocean, 76 mm/yr for the Indian Ocean and 43 mm/yr for the Atlantic Ocean which, although not equatorially or meridionally aligned, approximate the present-day calculated rate of 140 mm/yr increase in equatorial circumference.

For a hypothetical Earth increasing its radius as a function of a constant Earth mass, density (Figure 12, Curve B) is shown to decrease exponentially from a peak of approximately 290 grams/cm^3 during the Precambrian, to a present value of 5.52 grams/cm^3 and approaches zero at about 300 million years in the future. Assuming that the universal gravitation G is constant, or near constant throughout Earth's history, surface gravity (Figure 12, Curve C) is shown to decrease exponentially from a peak value of approximately 138 metre sec^{-2} during the Precambrian, to 95 metre sec^{-2} during the Cambrian, 9.8 metre sec^{-2} during the present-day and approaches zero at about 300 million years in the future.

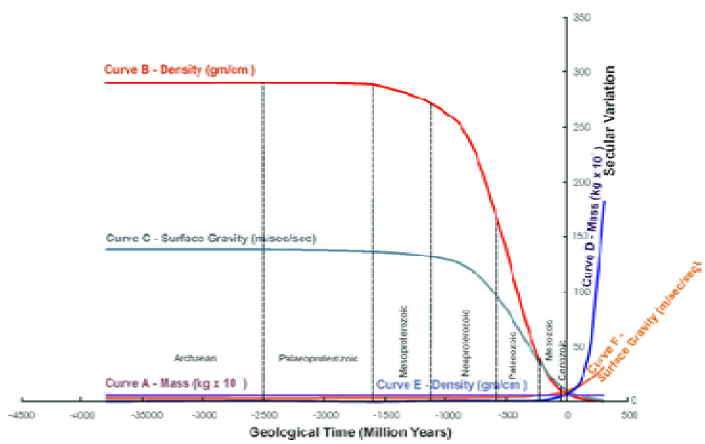

Fig. 12. Kinematics of mass, density and surface gravity. Graphs are shown for conditions of constant mass (Curves A, B, C) and exponentially increasing mass (Curves D, E, F). The graphs suggest that an increasing mass scenario is more representative of the planets within the present Solar System and qualifies the conclusions of Carey (1983) [13].

For a hypothetical Earth increasing its radius as a function of constant density, mass (Figure 12, Curve D) is shown to increase exponentially from approximately 1.1 x 10^{23} kilograms during the Precambrian, to a present value of 5.97 x 10^{24} kilograms and 190 x

10^{24} kilograms at about 300 million years in the future. Assuming that G is constant, or near constant throughout Earth's history, surface gravity (Figure 12, Curve F) is shown to increase exponentially from approximately 2.6 metre sec^{-2} during the Precambrian, to approximately 30 metre sec^{-2} at about 300 million years in the future.

The kinematics of mass, density and surface gravity shown in Figure 12 represent end-points of possible causes of Earth expansion. Without additional cosmological constraints the exact kinematics, and hence cause of Earth expansion is, at this stage, indeterminate. At a constant mass, the Earth's density and surface gravity during the Precambrian is shown (Figure 12) to be excessively high when compared to the densities and surface gravity of the present Sun and outer planets of the Solar System. Carey concluded, because of the limitations of surface gravity in the past, there may be no alternative but to consider an exponential increase in Earth mass with time as the primary cause of increasing Earth radius.

Assuming an increasing mass scenario, on an Expansion Tectonic Earth, surface gravity during the Precambrian Eras would be about one third of the present value and about one half of the present value during the Mesozoic Era. The Mesozoic Era of course was the Era of the dinosaurs, those very large, very long bodied creatures who could very well have benefited from a much lower surface gravity. Projecting an increasing Earth mass scenario to the future suggests that the Earth would then approach the size of Jupiter and Saturn within about 500 million years. During this interval of time the Earths' oceans, and the volatile elements presently retained in the crust and mantle, may simply evaporate to form a thick gaseous envelope or ring structure, similar to those of the present giant planets.

This scenario would be subdued slightly if a density gradient were superimposed on the data, declining in time from higher rocky planet densities to lower giant gaseous planet densities.

This increasing mass scenario then suggests that the transition from an inner rocky planet to a giant gaseous planet may be a natural evolutionary planetary process in our Solar System. If the Earth radius were increasing it would then seem that our Earth may be currently in a transitional phase, and is likely to end up as either another giant planet, or perhaps, as has been suggested by Carey, a "*failed planet*" such as the asteroid belt might resemble.

Professor Carey therefore previously concluded from his own research that, because of the limitations shown from estimates of our ancient surface gravity, there may be no alternative but to consider an exponential increase in Earth mass with time, as both the primary cause and effect of Earth expansion.

If we adopt this constant density and increasing mass scenario for the cause of an increasing Earth radius, as proposed by Carey, the present annual rates of increase in mass and surface gravity are then calculated to be:

Mass	$dM/dt_0 = 60 \times 10^{12}$ tonnes/year
Surface gravity	$dg/dt_0 = 3.4 \times 10^{-8}$ $msec^{-2}$/year

Without additional cosmological constraints the exact changes, and hence cause of increasing Earth mass at this stage cannot be determined with any degree of certainty. While an increase in Earth mass appears to be the most acceptable scenario by most researchers, it also begs the very pertinent, and natural question as to where did all this new matter come from?

3. Proposed Causal Model for Earth Expansion

Concerning the physical cause of Earth expansion Creer (1965) [20] professed that, "*we should beware of rejecting the hypothesis of Earth expansion out of hand on grounds that no known sources of energy are adequate to explain the expansion process*". Creer further considered that, "*it may be fundamentally wrong to attempt to extrapolate the laws of physics as we know them today to times of the order of the age of the Earth and of the Universe*". While Carey (1976) [21] stated that he "*may not necessarily be expected to know*" the cause of Earth expansion, since the answer can only be known "*if all relevant fundamental physics are already known*" - which they clearly are not.

These concerns remain equally true today since historically, in the evolution of knowledge, empirical phenomena have often been recognized long before their cause or reason has been fully understood. Most humans of course instinctively want to know, or at least comprehend a cause well before acknowledging any physical evidence. The recognition and introduction of Darwin's theory of evolution for instance, is a good example of our instinctive hesitation to change.

The theory of Earth expansion was first proposed in the 1890s. Since then five main re-occurring themes for the cause of Earth expansion have been suggested. The potential causes of Earth expansion were investigated and extensively reviewed by Carey (1983) [13]. The themes considered include:

1. A pulsating Earth, where cyclic expansion of the Earth opened the oceans and contractions caused orogenesis. This proposal failed to satisfy exponentially waxing expansion. Carey considered the theme to have arisen from a misconception that orogenesis implies crustal contraction and saw no compelling evidence for intermittent contractions of the Earth.
2. Meteoric and asteroidal accretion. This was rejected by Carey as the primary cause of Earth expansion since expansion should then decrease exponentially with time. It also does not explain seafloor spreading.
3. A constant Earth mass with phase changes of an originally super-dense core. Carey rejected this because he considered the theme to imply too large a surface gravity throughout the Precambrian and Palaeozoic Eons.
4. A secular reduction of the universal gravitation constant, G. Such a decline of G was considered to cause expansion through release of elastic compression energy throughout the Earth and phase changes to lower densities in all shells. Carey again rejected this proposal as the main cause of expansion for three reasons: a) that surface gravity would have been unacceptably high; b) that the magnitude of expansion would probably be too small and; c) the arguments for a reduction in G were considered not to indicate an exponential rate of increase.
5. A cosmological cause involving a secular increase in the mass of the Earth.

Carey considered that the first four proposals for cause of Earth expansion are soundly based and may have contributed in part to an increase in Earth radius. Potential limitations on surface gravity in the past suggested to Carey that there may be no alternative but to consider an exponential increase of Earth mass with time as the main cause for expansion. Where the excess mass came from was considered at length and Carey suggested that new mass added to the Earth must occur deep within the core. The ultimate cause of Earth expansion must however be sought in conjunction with an explanation for the cosmological expansion of the Universe.

The suggested proposed causal model for Expansion Tectonics (Figure 13), while still largely speculative is closely related to matter generation within a plasma dominated Universe. In plasma dominated Universe the Earth is under constant bombardment from space, especially from the Sun, with all the necessary components (anions and cations) necessary to reconstitute matter from its component parts penetrating deep within the Earth. The Earth, having a strong magnetic field, gathers more than sufficient fundamental particles to account for an increase in matter internally over billions of years. It is suggested that this new matter accumulates at the core-mantle interface and the increase in new volume results in swelling of the mantle. This proposal is borne out by seismic and tomographic evidence by others whereby the core-mantle interface is shown to be the most active part of the Earth's interior.

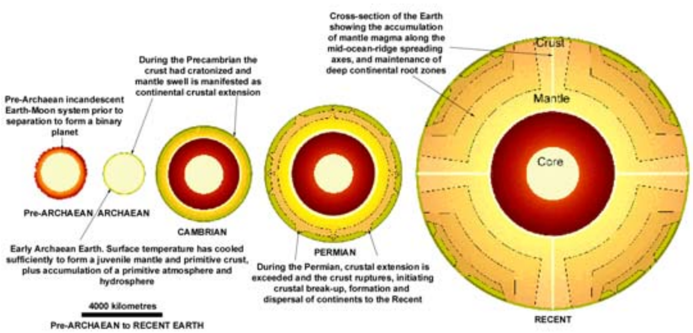

Fig. 13. Schematic cross-sections through the Expansion Tectonic Earth showing crustal extension, sea-floor spreading and opening of the modern oceans in relation to mantle swell.

In this proposal, matter generation within the Earth's core is an ongoing process, resulting in mantle swell. Mantle swell is then manifested in the outer crust as crustal extension, and is currently occurring as extension along the mid-ocean-rift zones. It is speculated that this process may ultimately decay with time, depending on the evolution of the Sun, and may ultimately reverse the present exponential increase in Earth radius and cease expansion in the distant future.

3.1 A Challenge to Physics

While geology empirically demonstrates that the concept of an Earth increasing its radius with time is a viable tectonic process, the problem of where the excess matter comes from to increase Earth mass over time remains a very real enigma. This question continues to thwart any acceptance, or consideration of any form of Earth expansion, simply because no motor or mechanism for increase in Earth radius has been forthcoming. Why? Because the question has never been asked, and hence physics has never been required to take the problem seriously.

The challenge I pose to physics is, disregarding the instinctual hesitation towards considering any form of increasing Earth radius scenario, especially with the amount of established research in support of Plate Tectonics, what mechanisms are available to explain the undeniable empirical geological evidence?

4. Conclusion

Reconstructions of oceanic and continental geology on models of an Expansion Tectonic Earth demonstrate that crustal plates can be latitudinally and longitudinally constrained with only one plate fit-option on an Earth at reduced radii. Post-Triassic reconstructions of crustal plates constrained by seafloor mapping consistently show a plate fit-together at better than 99% fit for all plates.

Mathematical modeling of crustal surface area data provides a means to accurately qualify a rate of change of Earth radius from the Archaean to Recent. The Earth is shown to be undergoing an exponential increase in radius, commencing from a primordial Earth of approximately 1700 kilometres radius during the Early Archaean. The current rate of increase in Earth radius is calculated to be 22 millimetres per year. Extrapolation of radius to the future suggests that the Earth will increase to the size of Jupiter within approximately 500 million years.

Despite the enigmatic origin for the excess matter required for expansion, global geological and geophysical data quantify and substantiate an Archaean to Recent Earth expansion process. It is concluded that this cannot be mere coincidence. In order to accept Expansion Tectonics as a viable global tectonic process, we must, however be prepared to remove the constant Earth radius premise from tectonic studies, thus encouraging the physical sciences to promote active research into the motor and mechanism behind Earth expansion.

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Figures

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