EXAMINATION OF MAXLOW'S MODEL FOR EXPANSION TECTONICS – AN ASTRONOMICAL PERSPECTIVE

Dr. Raymond HV Gallucci, PE
gallucci@localnet.com

In his latest book, Global Tectonic Data Modeling, Maxlow examines the interplay among mass, density and surface gravity on an expanding Earth. [1] In particular, he addresses three possible scenarios to represent potential changes in Earth's mass and density, and the resulting effect on surface gravity, for an Earth whose radius has increased by a factor of 3.75 exponentially over the past 1.6 x 10^9 years: (1) Constant mass, with corresponding decrease in density due to volumetric increase as the third power of an exponentially increasing radius; (2) Constant density, with corresponding mass increase due to same volumetric increase as for (1); and (3) Both mass and density variable, with same corresponding volumetric increase as in (1) and (2). In all three scenarios, Earth's volume has to increase by a factor of $3.75^3 = 52.7$ over the 1.6 x 10^9 years. For an exponentially increasing radius by a factor of 3.75, the corresponding exponential increase constant "k" would be as follows:

$$R(t) = R_0 e^{kt},$$

$$where\ R(t) = radius\ at\ time\ t\ relative\ to\ starting\ radius\ R_0\ 1.6x10^9\ years\ ago\ (t = 0)$$

$$k = \frac{\ln(R[1.6x10^9]/R_0)}{1.6x10^9 y} = \frac{\ln(3.75)}{1.6x10^9 y} = 8.26x10^{-10}/y$$

In Scenario (1), the volumetric increase requires a corresponding density decrease by the factor of 52.7, with a resulting decrease in surface gravity by a factor of $3.75^2 = 14.1$. Given lower gravity is often cited as one alternative explanation for the immense size of land dinosaurs in the past (another is a much thicker atmosphere providing enhanced buoyancy such that the land creatures were effectively "swimming" in air [e.g., [2]), this scenario seems highly unlikely, even during the last phase of the Cretaceous around 6.5 x 10^7 years ago. At this time, the exponentially increasing radius would have risen by a factor of only

$$\frac{R(6.5x10^7)}{R_0} = e^{([8.26x10^{-10}][6.5x10^7])} = 1.06$$

implying that surface gravity would still have been $\left(\frac{1}{1.06}\Big/\frac{1}{3.75}\right)^2 = \left({}^{3.75}\!/_{1.06}\right)^2 = 12.6$ times greater than today. Therefore, Scenario (1) does not appear plausible.[1]

In Scenario (2), the same volumetric increase requires a corresponding mass increase by the factor of 3.75^3 = 52.7, with a resulting increase in surface gravity by a factor of ${}^{3.75^3}\!/_{3.75^2} = 3.75$, much more in line with the concept of lower gravity in the distant past, at least when the dinosaurs flourished. At 6.5 x 10^7 years ago, the surface gravity would have still been only $1.06/3.75 = 0.281$ of today's value, just slightly more than one-fourth. If one accepts the large increase factor in Earth's mass over the past 1.6 x 10^9 years, this scenario seems plausible.[2]

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1 Maxlow also concludes that, with continued exponential Earth expansion at the same rate, Earth would effectively dissipate into nothing in "only" another 3 x 10^8 years.

2 This may need to be tempered somewhat with Maxlow's estimate that Earth would approach the size of Jupiter or Saturn in the next 5 x 10^8 years, with possible evaporation of the oceans and gaseous elements currently retained in the crust and mantle forming a thick atmosphere or ring structure not unlike those of the current "gas giant" planets. Maxlow does observe that "[t]his scenario may be subdued slightly if a density gradient were

Because, at the present time, both the mass and density variables cannot be determined, Maxlow does not examine the third scenario. However, as an alternative, consider a scenario where the surface gravity remains constant over the past 1.6 x 10^9 years while the radius increases exponentially by the factor of 3.75. For constant surface gravity (measured for a unit mass of 1 kg at the surface),

$$\frac{dg}{dt} = \frac{d}{dt}\left(\frac{Gm(1)}{r^2}\right) = G\left(\frac{1}{r^2}\frac{dm}{dt} - \frac{2m}{r^3}\frac{dr}{dt}\right) = 0$$

where "G" is the universal gravitational constant, "m" is Earth's mass and "r" is Earth's radius. This simplifies to

$$\frac{dm}{m} = \frac{2dr}{r}$$

which, after integrating (assuming initial mass and radius of m_0 and r_0) becomes

$$\frac{m}{m_0} = \left(\frac{r}{r_0}\right)^2$$

Since $m = \frac{4}{3}\pi r^3 \rho$, where ρ = density, this can be expressed as

$$\frac{4\pi\rho r^3}{4\pi\rho_0 {r_0}^3} = \left(\frac{r}{r_0}\right)^2 \rightarrow \frac{\rho}{\rho_0} = \frac{r_0}{r} \rightarrow \rho r = \rho_0 r_0 = constant$$

where ρ_0 is the initial density. This represents a hyperbolic dependence between density and radius. For example, if Earth's radius has increased by a factor of 3.75 over the past 1.6 x 10^9 years, its density has to have decreased by this same factor. This implies a somewhat more modest increase in mass by a factor of "only" $\left(\frac{\rho}{\rho_0}\right)\left(\frac{r}{r_0}\right)^3 = \frac{1}{3.75}3.75^3 = 3.75^2 = 14.1,$ vs. the required increase by a factor of 52.7 in "plausible" Scenario (2). This is still a significant increase in mass, and the repercussions need to be examined from an astronomical perspective beyond Maxlow's exhaustive "Earth-based" examination, which includes (paleo-)geology, paleomagnetics, space geodetics, paleogeography, paleoclimatology, paleobiology, fossil fuels, past extinctions and metallogenics.

CONSERVATION OF ORBITAL ANGULAR MOMENTUM

First addressed informally by Rebigsol [3], one physical phenomenon on an astronomical scale expected to be satisfied is the conservation of the Earth's angular momentum in its orbit about the Sun as its mass increased (ignoring the Moon). Relative to the Sun, the Earth can be considered as a point mass "m" at a distance "d" (average orbital distance) with an angular speed "ω" and corresponding orbital period $T = 2\pi/\omega$, for which the angular momentum is $L = md^2\omega = 2\pi md^2/T$. Conservation of orbital angular momentum between 1.6 x 10^9 years ago and today requires that

$$\frac{md^2}{T} = \frac{\mu\delta^2}{\tau}$$

We can rewrite this as

superimposed on the data, declining in time from higher rocky planet densities to lower giant gaseous planet densities." [1]

$$\left(\frac{T}{\tau}\right)\left(\frac{\delta}{d}\right)^2 = \frac{m}{\mu}$$

where m, d and T represent the Earth today and μ, δ and τ, respectively, represent the Earth 1.6 x 10^9 years ago.

Above, two estimates for the mass increase were generated, a more "modest" factor of 14.1 and an "extreme" of 52.7. Setting m/μ equal to these two values, and assuming that Earth's orbital period has not changed (T/τ = 1), then δ/d = 1.93 for the "modest" mass increase and 7.26 for the "extreme" one. The first estimate would place Earth 1.6 x 10^9 years ago roughly halfway between the orbit of Mars (1.5 A.U.) and the inner radius of the asteroid belt (2.2 A.U. [4]). That is quite a displacement. The second would place it between the orbits of Jupiter and Saturn (5.2 A.U. and 9.6 A.U., respectively), beyond any level of credibility. Therefore, if the Earth's orbital period has not changed over the past 1.6 x 10^9 years, its mass cannot have increased by the "extreme" amount, and is stretching credulity even for the "modest" one.

What if it is the distance, and not the orbital period, that remained constant (i.e., δ/d = 1)? Under the "modest" mass increase, Earth's orbital period 1.6 x 10^9 years ago would have been shorter by a factor of 14.1, i.e., 26 instead of 365 days (just under a "Moon month"). For the "extreme" increase, the reduction factor would be 52.7, reducing the orbital period from 365 to 7 days, i.e., a week. Once again, the "extreme" mass increase yields a result based on conservation of orbital angular momentum that is beyond credibility. The "modest" increase stretches credulity as before. Can there be a combination of the key variables for orbital angular momentum that combine in such a way as to provide a credible scenario for an expanding Earth at both 1.6 x 10^9 years ago and today?

Expressing mass as previously, i.e., $m \propto r^3\rho$, the four variables for conservation of orbital angular momentum yield the following equation:

$$\frac{r^3\rho d^2}{T} = \frac{\gamma^3\sigma\delta^2}{\tau}$$

with the new variables r and γ representing Earth's radii and ρ and σ Earth's density today and 1.6 x 10^9 years ago, respectively. We can rewrite this as

$$\left(\frac{r}{\gamma}\right)^3\left(\frac{\rho}{\sigma}\right)\left(\frac{\tau}{T}\right)\left(\frac{d}{\delta}\right)^2 = 1$$

What combinations of these four ratios, when each is constrained to a "reasonable" range of values, might satisfy conservation of orbital angular momentum? Maxlow has already set the upper limit on $\gamma/r = 3.75$. Let us consider a range by a factor of three with three values, a minimum ratio of 1.25, and intermediate of 2.50 and this Maxlow maximum of 3.75. Ignoring the "gas giants" and Pluto, planetary densities for the four inner "rocky" planets range from Mars' minimum of 3.93 kg/m^3 to Earth's maximum of 5.51 kg/m^3, i.e., 1.40 times higher. With radius increasing as much as a factor of 3.75, and Earth's surface gravity inversely proportional to the square of its radius, maintaining a surface gravity that has not risen by more than the earlier Scenario (2) factor of 3.75 suggests a similar range and set of three values for Earth density as for its radius, i.e., $\sigma/\rho = 1.25, 2.50\ and\ 3.75$, recalling that ρr = 1 (an inverse proportionality). For distance from the Sun, we previously estimated for the "modest" increase a ratio nearly double Earth's current distance, i.e., beyond the orbit of Mars. Limiting that range to the orbit of Mars without the Earth having ever been any closer than it is today suggests a range and set of three values for Earth orbital distance as $\delta/d = 1.00, 1.25\ and\ 1.50$. Paralleling this and noting that Mars' current orbital period of 687 days in a factor of 1.88, or approximately double, that of Earth's, assume a range and set of three values for Earth orbital period as $\tau/T = 1.00, 1.50\ and\ 2.00$. Substituting each possible triplicate for each ration in the conservation of angular momentum equation yields $3^4 = 81$ possible combinations. Of these, only four yield results equal or very close (within 10%) of 1.00.

The first combination is as follows:

$$\left(\frac{r}{\gamma}\right)^3\left(\frac{\rho}{\sigma}\right)\left(\frac{\tau}{T}\right)\left(\frac{d}{\delta}\right)^2 = \left(\frac{1.25}{1.00}\right)^3\left(\frac{1.00}{1.25}\right)\left(\frac{1.00}{1.00}\right)\left(\frac{1.00}{1.25}\right)^2 = 1.00$$

Here, we have a "very modest" increase over the past 1.6 x 10^9 years in radius by a factor of only 1.25, an equivalent decrease in density, no change in the orbital period, and a decrease in orbital distance also by the factor of 1.25. No parameter governing Earth's orbital angular momentum has changed by more than a factor of 1.25, which will turn out to be the "simplest" combination that preserves Earth's orbital angular momentum.

Here is the second combination:

$$\left(\frac{r}{\gamma}\right)^3\left(\frac{\rho}{\sigma}\right)\left(\frac{\tau}{T}\right)\left(\frac{d}{\delta}\right)^2 = \left(\frac{1.25}{1.00}\right)^3\left(\frac{1.00}{2.50}\right)\left(\frac{2.00}{1.00}\right)\left(\frac{1.00}{1.25}\right)^2 = 1.00$$

Again Earth's radius increases very modestly by a factor of 1.25, but we have more significant changes in its density (a decrease by factor of 2.50) and orbital period (an increase by a factor of 2.00), while orbital distance is again decreased by a factor of 1.25. This combination requires more drastic changes in two of the ratios, one by as much as a factor of 2.50.

The third combination yields a result close, but not exactly equal, to 1.00:

$$\left(\frac{r}{\gamma}\right)^3\left(\frac{\rho}{\sigma}\right)\left(\frac{\tau}{T}\right)\left(\frac{d}{\delta}\right)^2 = \left(\frac{1.25}{1.00}\right)^3\left(\frac{1.00}{1.25}\right)\left(\frac{1.50}{1.00}\right)\left(\frac{1.00}{1.50}\right)^2 = 1.04$$

Earth's radius again increases by only the very modest factor of 1.25. The density decrease is the same as in the first combination, the minimum assumed ratio of 1.25. The increase in orbital period is the intermediate factor of 1.50. This is also the same factor for the decrease in orbital distance, which represents the maximum of the assumed range. Similar to the first combination, this one is also relatively "simple," in that no ratio changes by more than a factor of 1.50.

The final combination again yields a result close, but not exactly equal, to 1.00:

$$\left(\frac{r}{\gamma}\right)^3\left(\frac{\rho}{\sigma}\right)\left(\frac{\tau}{T}\right)\left(\frac{d}{\delta}\right)^2 = \left(\frac{1.25}{1.00}\right)^3\left(\frac{1.00}{3.75}\right)\left(\frac{2.00}{1.00}\right)\left(\frac{1.00}{1.00}\right)^2 = 1.04$$

As in the previous combinations, Earth's radial increase is very modest (a factor of 1.25). The orbital period doubles as in the second combination, but now the orbital distance is unchanged while the density decreases by its largest factor of 3.75. This combination requires the most drastic change in a ratio, that being a density decrease by a factor of 3.75.

Of particular note in all four cases is that the Earth's radius increases only "very modestly," i.e., by no more than a factor of 1.25, or one-third of the Maxlow "maximum." This suggests a possible need to revisit the geologic and other data used to estimate Earth's radial increase over the past 1.6 x 10^9 years in order to align with conservation of orbital angular momentum (or to assume this is not conserved).

CONSERVATION OF ROTATIONAL ANGULAR MOMENTUM

The rotational angular momentum of the Earth (again ignoring the Moon) can be modeled approximately as that of a solid sphere, i.e.,

$$L = \frac{2}{5}mr^2\omega = \frac{16}{15}\pi^2\rho r^5/T$$

using $m = \frac{4}{3}\pi\rho r^3$ and $\omega = \frac{2\pi}{T}$. Assuming conservation of rotational angular momentum, obtain

$$\frac{dL}{dt} = 0 = \frac{5r^4}{T}\frac{dr}{dt} - \frac{r^5}{T^2}\frac{dT}{dt}$$

assuming a relatively constant Earth density. Since both r > 0 and T > 0, this reduces to

$$5\frac{dr}{dt} = \frac{r}{T}\frac{dT}{dt} \rightarrow \frac{dT}{T} = 5\frac{dr}{r}$$

Integration between time t = 0 (1.6 x 10^9 years ago) and some subsequent time "t" yields

$$T(t) = T_0\left(\frac{r(t)}{r_0}\right)^5$$

With T_0 and r_0 being the Earth's rotational period and radius at t = 0 (1.6 x 10^9 years ago). What we know is that, today, Earth's rotational period is 24 h and, by Maxlow's estimate, its radius is 3.75 times larger. With these,

$$T_0 = \frac{T(1.65\ x\ 10^9)}{3.75^5} = \frac{24\ h}{742} = 0.0324\ h = 1.94\ min$$

which would be incredibly fast and beginning to approach rotational rates for much denser stellar objects, such as white dwarfs.[3] [5] With the "very modest" radial increase by a factor of only 1.25 as suggested by the analysis for conservation of orbital angular momentum, this estimate is 7.86 h, or about one-third of the current length of a day, with the realm of credibility, even for an Earth only slightly smaller. Jupiter, despite its immense size, rotates with a period of 9.9 h, so a much smaller, "solid" planet such as Earth should have been able to exhibit a similar rotation rate. The rotation period at the end of the dinosaurs' reign 6.5 x 10^7 years ago under this "very modest" growth assumption would still be quite short, 7.94 h for exponential growth or 9.43 h for linear growth.

SUMMARY

Maxlow's extensive analysis of (paleo-)geology, paleomagnetics, space geodetics, paleogeography, paleoclimatology, paleobiology, fossil fuels, past extinctions and metallogenics suggest that Earth's radius has grown exponentially over the past 1.6 x 10^9 years by a factor of 3.75, with sufficient increase in mass to ensure that surface gravity has not decreased, and quite possibly has increased. A much more cursory examination of this assumption from the perspective of astronomical physics, particularly conservation of Earth's orbital and rotational angular momentum, suggests a much more "modest" rate of increase, not necessarily exponential. And, while quite limited in comparison to Maxlow's analysis, this simplified one still raises apparently valid discrepancies that should be addressed. Hopefully, further research and

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[3] Rotational periods as short as 0.012 day (star GD 140) are reported from spectroscopic observations for white dwarf stars. [5]

analysis, or validation of different assumptions, can bring these two competing arenas into closer agreement.

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Appendix I – Mathematical Examination of Maxlow's Proposed Mechanism for Earth Mass Increase

Maxlow adopts the premise that, given the outflow of particles from the Sun in the form of a plasma "solar wind," absorption of these particles within the Earth can explain the mechanism for mass increase. "The total number of magnetised particles carried away from the Sun by the solar wind is now estimated to be about 1.3×10^{36} per second. From this, the total mass loss of the Sun each year is estimated by others to be about 4 to 6 billion tonnes per hour, or 35 to 53 trillion tonnes per year. This is equivalent to losing a mass equal to the Earth every 150 million years, or conversely providing a mechanism to double Earth radius in the past 250 million years." [1] "The solar wind is a stream of charged particles released from the upper atmosphere of the Sun. This plasma consists of mostly electrons, protons and alpha particles with thermal energies between 1.5 and 10 keV." [8] This suggests that an upper bound on the mass released from the Sun can be estimated by assuming the solar wind to consist exclusively of alpha particles. With a mass of $6.64 \text{ x } 10^{-27}$ kg per alpha, the solar wind mass flux at Earth's distance from the Sun ($1.50 \text{ x } 10^{11}$ m) becomes

$$(1.3\,x\,10^{36}/s)(6.64\,x\,10^{-27}kg)\Big/4\pi(1.50\,x\,10^{11}m)^2 = 3.07\,x\,10^{-14}\,kg/m^2s$$

Assuming all are absorbed by the Earth over its total surface area (assume the alphas can "curve" around to the "far side" due to Earth's magnetic field, so as to be absorbed there as well), the absorption rate becomes

$$(3.07\,x\,10^{-14}\,kg/m^2s)(4\pi[6.371\,x\,10^6 m]^2) = 15.7\,kg/s$$

which amounts to a total mass absorption over $1.6 \text{ x } 10^9$ y of $7.90 \text{ x } 10^{17}$ kg, or $1.32 \text{ x } 10^{-7}$ of Earth's current mass ($5.97 \text{ x } 10^{24}$ kg). Clearly this is impossibly too low to constitute the alleged increase in Earth mass by a factor of 3.75 over the past $1.6 \text{ x } 10^9$ y.

Somewhat less pessimistic is an estimate based on the total mass of the Sun that has been released and what would need to have been absorbed by the Earth to have only doubled in size over the past $1.6 \text{ x } 10^9$ y. To have doubled to today's size, Earth's mass, assuming constant density, 1.6 x 10^9 years ago would have had to have been $5.97x\ 10^{24} kg/2^3 = 7.47\ x\ 10^{23} kg$, or 5.23 x 10^{24} kg lighter. With the Sun emitting $(1.3\ x\ 10^{36}/s)(6.64\ x\ 10^{-27} kg) = 8.64\ x\ 10^9\ kg/s$ of mass, the Earth would have to have absorbed

$$\frac{5.23\ x\ 10^{24} kg}{(8.64\ x\ 10^9 kg/s)(60^2 x24x365x[1.6\ x\ 10^9]s)} = 0.0120$$

i.e., around 1% of the total mass released by the Sun (equivalent to 2.36 x 10^{-6} of the Sun's total mass [1.99 x 10^{30} kg]). Such a fraction is conceivable, but clearly this does not allow for the inverse squared decrease in the solar wind flux with distance, but assumes at least 1% of the released particles from the Sun remain available for Earth's absorption 1.50 x 10^{11} m away (despite a drop in flux by a factor of $\left[\frac{1.50\ x\ 10^{11} m}{6.96\ x\ 10^8 m}\right]^2 = 4.62\ x\ 10^4$).

The previous two estimates were based on the "solar wind." The Earth is actually "bathed" in "cosmic rays," which "… is the term given to high energy radiation which strikes the Earth from space. Some of them have ultrahigh energies in the range 100 - 1000 TeV. Such extreme energies come from only a few sources like Cygnus X-3. The peak of the energy distribution is at about 0.3 GeV ... Almost 90% of the cosmic rays which strike the Earth's atmosphere are protons (hydrogen nuclei) and about 9% are alpha particles. Electrons amount to about 1% … [with] a small fraction of heavier particles which yield some interesting information. About 0.25% are light elements (lithium, beryllium and boron) …" [9]

From Reference [10], "[t]he table below gives estimates of the particle flux at a time of minimum sunspot activity (when the flux is highest, as in 1965, 1977, 1987 [listed under the heading "max" in the table below]) and also (in italics) for a period of near maximum solar activity (low flux—though there is no well-defined absolute minimum [listed under the heading "min" in the table below]) ... [The fluxes in columns 2 through 5] are quoted for protons and .... for the aggregate of all nuclear particles (including protons). Some compromises between inconsistent data mean that … [the fluxes] are not always exactly consistent: errors of ~15% may be present in the fluxes for nuclei and protons: the uncertainties for electrons are much larger."[4]

Energy (GeV)	**Proton Flux (particles/m²s)**		**Nuclei Flux (particles/m²s)**		**Integrated Proton Flux (particles/m²s)**		**Integrated Nuclei Flux (particles/m²s)**	
	max	***min***	**max**	***min***	**max**	***min***	**max**	***min***
0.1	2900	*1300*						
0.2	2800	*1300*			285	*130*		
0.5	2300	*1200*	2600	*1400*	765	*375*		
1	1700	*1000*	2000	*1100*	1000	*550*	1150	*625*
2	1000	*700*	1200	*830*	1350	*850*	1600	*965*
5	410	*340*	540	*420*	2115	*1560*	2610	*1875*
10	180	*160*	240	*210*	1475	*1250*	1950	*1575*
20	62	*58*	95	*85*	1210	*1090*	1675	*1475*
100	3.8	*3.7*	7.6	*7.3*	2632	*2468*	4104	*3692*
1000	0.67	*0.67**	0.16	*0.16**	2011.5	*1966.5*	3492	*3357*

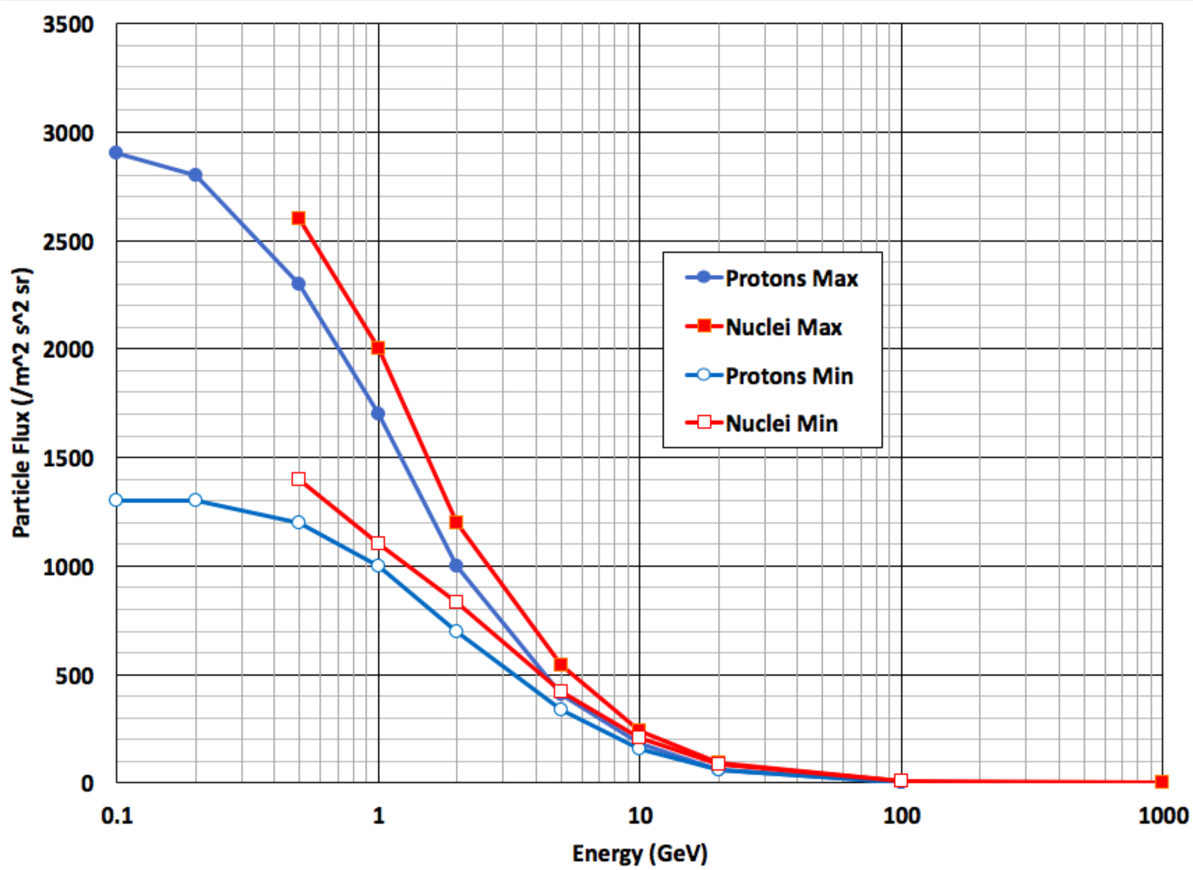
* Assumed the same as max.

4 Given electrons are nearly 2000 times less massive than protons, and their listed fluxes are at least an order of magnitude lower than those for protons and all nuclei, the electron contribution to cosmic rays is omitted.

Columns 2 through 5 show the proton and nuclei fluxes at discrete values of energy and can be plotted as shown in the following figure for both the maxima and minima. To estimate the total fluxes, the approximate areas "A" under the curves can be integrated for each reported energy increment as follows:

$$A(E_1 \rightarrow E_2) = \frac{\phi_1 + \phi_2}{2}(E_2 - E_1)$$

where E_1 and E_2 are two consecutive energy levels with corresponding fluxes ϕ_1 and ϕ_2. Columns 6 through 9 in the table show the results of these incremental integrations.



To estimate the total mass flux "Φ" over the energy range from 0.1 through 1000 GeV, the contribution from the protons alone up through 0.5 GeV are combined with the total from all nuclei up through 1000 GeV assuming proton mass (1.67×10^{-27} kg) for the protons and alpha mass for the nuclei (6.64×10^{-27} kg), i.e.,

$$\Phi(0.1 \rightarrow 1000\ GeV) = (1.67\ x\ 10^{-24} kg)\ x \sum_{0.1\ GeV}^{0.5\ GeV} A\,(E_i \rightarrow E_{i+1}) + (6.64\ x\ 10^{-27} kg)\ x \sum_{0.5\ GeV}^{1000\ GeV} A(E_i \rightarrow E_{i+1})$$

The resultant total mass fluxes (kg/m^2s) are 1.12×10^{-22} (maximum), 9.10×10^{-23} (minimum) and 1.01×10^{-22} (average). The difference between the maximum and minimum is < 25%, so use of the average, given the level of approximation in these calculations, will suffice. If the Earth absorbs all these cosmic rays over its entire surface (typically these are assumed to be incident via "cones" leading into the poles due to the shape of Earth's magnetic field), the total mass absorbed over 1.6×10^9 years becomes

$$(1.01\ x\ 10^{-22}\ kg/m^2 s)(4\pi[6.371\ x\ 10^6 m]^2)(\ 60^2 x 24 x 365 x[1.6\ x\ 10^9]s) = 2.61\ x\ 10^9 kg$$

This is over eight orders of magnitude lower than the first estimate (7.90 x 10^{17} kg), which has already been deemed impossibly low to account for any mass increase necessary to support Maxlow's model. Therefore, of the three analyses performed here, only the second, whereby the Sun's outflow of 1.3 x 10^{36} particles/s somehow gets preferentially directed toward the Earth, where at least 1% gets absorbed, might explain the mass increase needed for Maxlow's model.

Appendix II – Pure Speculation on a Possible Alternative

I label this as "pure speculation" and sequester it in an Appendix so as not to detract from the more mathematically-based analysis in the main body of this paper. It is an attempt to combine the evidence for an expanding Earth with the need to conserve angular momentum on an astronomical level. Assume that, following the Late Heavy Bombardment era, supposed to have concluded some 3.8 x 10^9 years ago, [6] Earth had reached its approximate current size (radius = 6371 km). Effectively any gravitational accretion of "planetesimals" or absorption of impacting asteroids was complete. To accommodate the evidence that all today's continents "retrofit" together, assume that Earth was a "water vapor world," i.e., completely surrounded by an atmosphere containing water vapor with a volume at least equal to that of today's oceans (1.33 x 10^9 km^3 [7]). Beneath this was a "solid" Earth, covered by a worldwide crust, essentially uniform in thickness and relatively "smooth."

Speculate that, shortly after the end of the LHB, the Earth's surface cooled sufficiently so that this 1.33 x 10^9 km^3 of water vapor condensed, causing the surface crust to "crack" due to thermal shock. The Earth's interior, still highly molten as a result of the LHB, began to flow upward through these cracks, causing the existing surface crust to begin compressing "surficially" (essentially laterally), with consequent "thickening" and "bulging" (especially in the downward direction, given today's continents supposedly extend for tens of kilometers downward vs. the maximum upward being the Himalayas, with Mt. Everest just under 9 km), consistent with what the contents are reputed to exhibit today. This "expansion" ("stretching/compressing") continued until the continents could be compressed no further, leaving the Earth's surface with its current configuration of 29% land and 71% ocean. Once that ratio was reached, "plate tectonics" took over, with any continental movement resulting from oceanic crust expansion and subduction.

An important corollary that allows the continental "retrofit" that supports the paradigm of a once "continental" Earth is that the Earth's surface was quite uniform when it "cracked" after the LHB. Therefore, the shapes of the continents formed by these cracks were preserved during the continental compressions, thereby enabling them to be "retrofit" so closely together today. Under this admittedly purely speculative model, perhaps some of the problems associated with both plate tectonics (e.g., Why do the continents "retrofit" so well on all sides? Why is significant subduction only exhibited along the Pacific Rim?) and expanding Earth (e.g., From where did the increasing mass arise? Where were the oceans?[5] What about surface gravity and astronomical physics?) may be solved.

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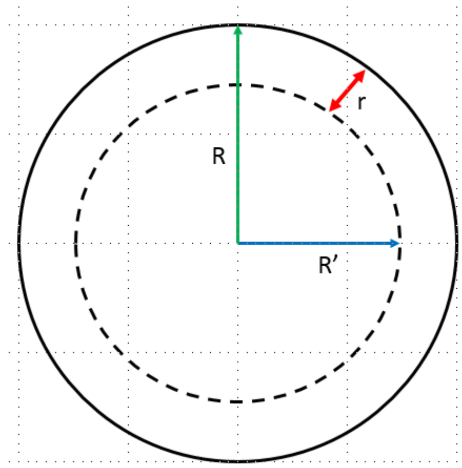
[5] Maxlow claims that today's oceans arose from "outgassing" of the original volcanic rock contained within the early "continental" Earth of radius 3.75 times smaller than today. [1] If true, just what fraction of this original Earth was comprised of water? The original volume of this early Earth would have been $\frac{4}{3}\pi\left(\frac{6371\ km}{3.75}\right)^3 = 2.05\ x\ 10^{10} km^3$. The oceans today comprise a volume of 1.33 x 10^9 km^3, or 6.5% of the original volume. So, if all the water in the oceans today arose from within the early "continental" Earth, meaning nothing need have been added as the mass accrued over the past 1.6 x 10^9 years (per Maxlow) to generate today's Earth with radius 3.75 times larger, this water need only have comprised a small fraction of continental Earth.



As an exercise, calculate the depth of the initial "world-wide" ocean after condensation and before significant crustal "compression" as a result of the cracking. From the figure, assume "continental" Earth had a radius = R', with a global oceanic "shell" of thickness "r," such that R = R' + r. Today's oceans have a volume "V" = 1.33×10^9 km^3, assumed to be the same volume of this initial global ocean.

$$V = \frac{4}{3}\pi R^3 - \frac{4}{3}\pi R'^3 = \frac{4}{3}\pi(R^3 - [R - r]^3) \rightarrow r^3 - 3r^2R + 3rR^2 = V/\frac{4}{3}\pi$$

With R = 6371 km, obtain r = 2.61 km, or 71% of today's average depth (3.68 km [7]), corresponding to the ocean's coverage of Earth's surface today.

Maxlow observes that volcanic rocks typically contain as much as 20% gasses and water in various forms, including chemical bonds, so releasing 6.5% of this original 20% is conceivable. Thus, this is consistent with the accepted theory that Earth acquired all its water very early in history (prior to and/or during the LHB?) from cometary impacts, etc. Any mass added afterward to grow the Earth to its present size need not have supplied much more water for today's oceans to have evolved as we see them today. And the need for an initial "water vapor world" would be eliminated, provided one assumes the water that comprises today's oceans was contained in various forms within "continental" Earth, consistent with Maxlow.