Expansion Tectonics – Is It All Wet?

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1. Introduction

The article "Mystery of Earth's Water Origin Solved" in 2014 reported that "Instead of arriving later by comet impact, Earth's waters have likely existed since our planet's birth … according to a [then] new study [1] of ancient meteorites … [that] found our seas may have arrived much earlier on our planet than previously thought. The study pushes back the clock on the origin of Earth's water by hundreds of millions of years, to around 4.6 billion years ago, when all the worlds of the inner solar system were still forming … 'The study shows that Earth's water most likely accreted at the same time as the rock [from meteorites from the large asteroid Vesta, which have the same chemistry as the carbonaceous chondrites and rocks found on Earth] … The planet formed as a wet planet with water on the surface'." [2]

Not long after this declaration, a team of scientists from multiple science institutes questioned this conclusion. "There are two big problems … The bulk of Earth's water, hidden deep underground, has a different composition from that of ocean water. Yet scientists use seawater to compare the makeup of Earth's water against that of icy asteroids and comets … To trace Earth's water to its source, researchers use … the D/H [deuterium to hydrogen] ratio … Deuterium shows up more frequently at lower temperatures, so the D/H ratio should be useful for figuring out how far from the sun Earth's water came … [T]he D/H ratio bounces all over the place as one moves farther from the sun … And no two calculations agree on what the D/H ratio was at any particular distance from the sun." [3]

Compounding this is the fact that "A range of D/H ratios are found on Earth … The hydrological cycle fractionates hydrogen, creating glacial ice, ocean water, and fresh water reservoirs. Subduction provides a means to mix water back into the mantle, producing a variation in δD [D/H ratio of sample relative to standard D/H ratio for Vienna Standard Mean Ocean Water] from -12.6 to +4.6% … In addition to dehydration, melt-inclusion degassing can also raise D/H ratios and lower water contents … Lithospheric slab dehydration during subduction and deep recycling can produce low D/H ratios …" [4] In summary, there is no accepted single value for the appropriate D/H ratio for Earth's water against which to compare ratios from other solar objects.

"Scientists don't really know how much water is locked away in the Earth. Estimates vary: anywhere from 1.5 times as much water as is found in the oceans to 11 times or more … 'If the geophysicists are right … there's a lot of water in the interior'." [3] "The lowest measured D/H value (δD = -21.8%) provides an upper limit on the D/H of early Earth … [that] was added to the Earth during initial accretion, via dust grains with absorbed H_2O inherited directly from the protosolar nebula (-8.70%). The temperature was high at Earth's orbital distance during the early solar system, but 1000 to 500 K would still allow adsorption of 25 to 300% of earth's ocean water onto fractal grains during Earth's accretion." [4]

Earlier studies by Mottl, an oceanographer in Hawaii trying to measure the amount of water on Earth,[1] leads to the following speculation. "In the upper mantle, or crust, there is water hiding in the tiny pores of certain 'hydrous' materials … Mottl figures there's maybe a fifth of a global ocean in the upper mantle. In the lower, bigger mantle, the calculations get more theoretical … but he guesses anywhere from one-tenth to 1.8 global oceans … [I]n the earth's core, nobody knows. There's enough capacity to house 60 oceans. Or

1 Also one of the authors of the subsequent study cited in Reference [4].

maybe 100 … [A] conservative (albeit blind) guess would be the earth today carries with it three global oceans of water, 1/3 on top … and 2/3 down below where it sits silently with the minerals." [5]

2. "Wet" Early Earth?

From the above estimates of the amount of water on and in the Earth, certainly quite speculative at this point, at least a reasonable estimate appears to be about three times the current ocean volume, or (3)(1.4 x 10^{21} kg) = 4.2 x 10^{21} kg.[2] Since water's density is 1 g/cc (1 x 10^{12} kg/km^3), this corresponds to a volume of 4.2 x 10^9 km^3, or 0.0038 of the Earth's current volume of 1.1 x 10^{12} km^3, with the corresponding mass fraction = 0.00070.[3]

Champions of Expansion Tectonics contend that the Earth was once smaller, based primarily on a rather near-perfect fitting of the continents together without the intervening oceans on a smaller globe.[4] Most proponents base estimates of an early Earth size on the current land area of the continents, usually including the continental shelves in the fitting, or approximately 1.8 x 10^8 km^2. [7, 8] The corresponding radius is then $\sqrt{1.8x10^8 km^2/4\pi}$ = 3800 km, or approximately 60% of Earth's current radius of 6400 km. Maxlow contends that early Earth had a much smaller radius of about 1700 km, or roughly 25% of today's radius, which is the smallest value so far proposed. [6] If Earth's mass, including its water, has remained constant, then it is clear that, while the mass fraction of water relative to the total mass has not changed from today's 0.0070, the volumetric fraction has ranged widely, from today's minimum of 0.0038, to $4.2x10^9 km^3/\frac{4}{3}\pi([0.60][6400\ km])^3$ = 0.018 for the "60%-radius Earth," to a potential maximum of $4.2x10^9 km^3/\frac{4}{3}\pi([0.25][6400\ km])^3$ = 0.24 for the "25%-radius Earth." These suggest a much "wetter" planet in the past, as well as a much denser one. Correspondingly, with smaller radii but the same total mass, surface gravity would have been much higher as well.

Consider two extremes for an earlier "wet" Earth, based on the estimate of three oceans worth of water on and in the planet. If all this water were contained within the planet, early Earth would have resembled a very wet, very dense "sponge," especially the 25%-radius version. At this extreme, the surface would have been essentially dry, as shown by the various projections of the continental fitting back in time by the Expansion Tectonics proponents. Volumetrically, the early Earth would have been one part water for every three parts "other" with an extreme density $(1/0.25)^3$ = 64 times greater than today. Surface gravity would have been $(1/0.25)^2$ = 16 times greater as well, possibly retaining a much thicker atmosphere with lighter gases. For the 60%-radius Earth, the "sponge" would have been drier and less dense, but still significantly more than today: $(1/0.60)^3$, nearly five times denser, with a surface gravity $(1/0.60)^2$, nearly three times greater.

The opposite extreme for an earlier "wet" Earth is a "waterworld," where all three oceans worth of water were on the surface, i.e., none within the planet. For the 25%-radius Earth, this suggests a worldwide ocean of depth $(0.25)(6400\ km) - \sqrt[3]{([0.25][6400\ km])^3 - (3)(4.2x10^9\ km^3)/4\pi}$ = 140 km, or nearly 10% of the radius. For the 60%-radius Earth, this suggests a worldwide ocean of depth $(0.60)(6400\ km) - \sqrt[3]{([0.60][6400\ km])^3 - (3)(4.2x10^9\ km^3)/4\pi}$ = 23 km, or around 0.6% of the radius. If today's Earth

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2 Reference [4] suggests a maximum initial adsorption of 300% of, or three times, Earth's current ocean water, corresponding to the very rough estimate cited in Reference [5] for the total amount of water in early Earth. This also lies at the lower end of the range from the additional 1.5 to 11 times of the Earth's current oceans lying inside the Earth as cited in Reference [4], i.e., a total of 2.5 to 12 times including the oceans.

3 Based on Earth radius = 6400 km and Earth mass = 6.0 x 10^{24} kg.

4 The geographic argument is by no means the only basis for Expansion Tectonics claims, as indicated by champions such as Maxlow in Reference [6].

were completely covered by three oceans worth of water, the depth would be $6400\,km - \sqrt[3]{(6400\,km)^3 - (3)(4.2x10^9\,km^3)/4\pi}$ = 8.2 km, or only about 0.1% of the radius. The surface gravity for each at the ocean's surface would be the same as for the "sponge" extreme. The interesting aspect is that either version, the "sponge" or "waterworld," would still be consistent with the nearly-perfect continental fitting espoused by advocates of Expansion Tectonics, although the "sponge" version is consistent with what is typically suggested (negligible surface water).

What do these two extremes imply for Expansion Tectonics? If the early Earth were a saturated "sponge," then there would have to have been phenomena that expelled roughly 2/3 of the totally contained water up through today to account for today's oceans. Contrary to what one typically thinks for a sponge, the sponge was initially compressed as much as possible, holding as much water as possible. Then, as it "swelled," water was released. If the early Earth were a "waterworld," then one sees a more credible phenomenon of the expanding "dry" interior absorbing up to 2/3 of the surface ocean until today, more consistent with how a "sponge" behaves when swelling up with water. Therefore, if Expansion Tectonics assumes early Earth contained all the water it has today (and this is not necessarily an assumption espoused by Expansion Tectonics[5]), then an early Earth starting out as a smaller waterworld seems more plausible.

3. An Expansion Mechanism?

"Scientists think that a large object, perhaps the size of Mars, impacted our young planet, knocking out a chunk of material that eventually became our Moon. This collision set Earth spinning at a faster rate. Scientists estimate that a day in the life of early Earth was only about 6 hours long. The Moon formed much closer to Earth than it is today. As Earth rotates, the Moon's gravity causes the oceans to seem to rise and fall. (The Sun also does this, but not as much.) There is a little bit of friction between the tides and the turning Earth, causing the rotation to slow down just a little. As Earth slows, it lets the Moon creep away." [9] As can be seen, the Earth's slowing from a rotation period very early in its history (perhaps around four billion years ago) to today's 24-hr period is usually attributed to the friction of the tides resulting from the Moon. Of course, this assumes Earth has remained essentially the same size throughout its history after initial formation and the collision which formed the Moon with essentially the same mass and, therefore, density. However, what if it is the conservation of Earth's rotational angular momentum that is the dominant cause? Might this support Expansion Tectonics?

For a solid, rotating sphere of mass 'M,' radius 'R' and rotational speed 'ω,' the angular momentum is $L = \frac{2}{5}MR^2\omega$, or in terms of the rotational period 'T,' $L = \frac{4\pi}{5}M\,R^2/T$. If angular momentum remains constant along with mass, then the relation between radius and period becomes $\frac{R_2}{R_1} = \sqrt{\frac{T_2}{T_1}}$. This implies that Earth's radius has effectively doubled with the factor of four increase in rotation period, fairly consistent with Expansion Tectonics (an early Earth with radius one-half today's). Correspondingly, the ratio of Earth's gravitational force on a 1 kg mass, $\Gamma = GM/R^2$, to the centrifugal force[6] on that same mass at the equator, $C = (2\pi/T)^2R$, becomes $\Gamma/_C = GMT^2/4\pi^2R^3$. When the parameters are expressed in consistent units, the results are as shown below for M = 6.0 x 10^{24} kg and R = 6400 km. Time is expressed dimensionlessly over a unitized range, but may be conveniently assumed to span four billion years with each increment comprising 400 million years.

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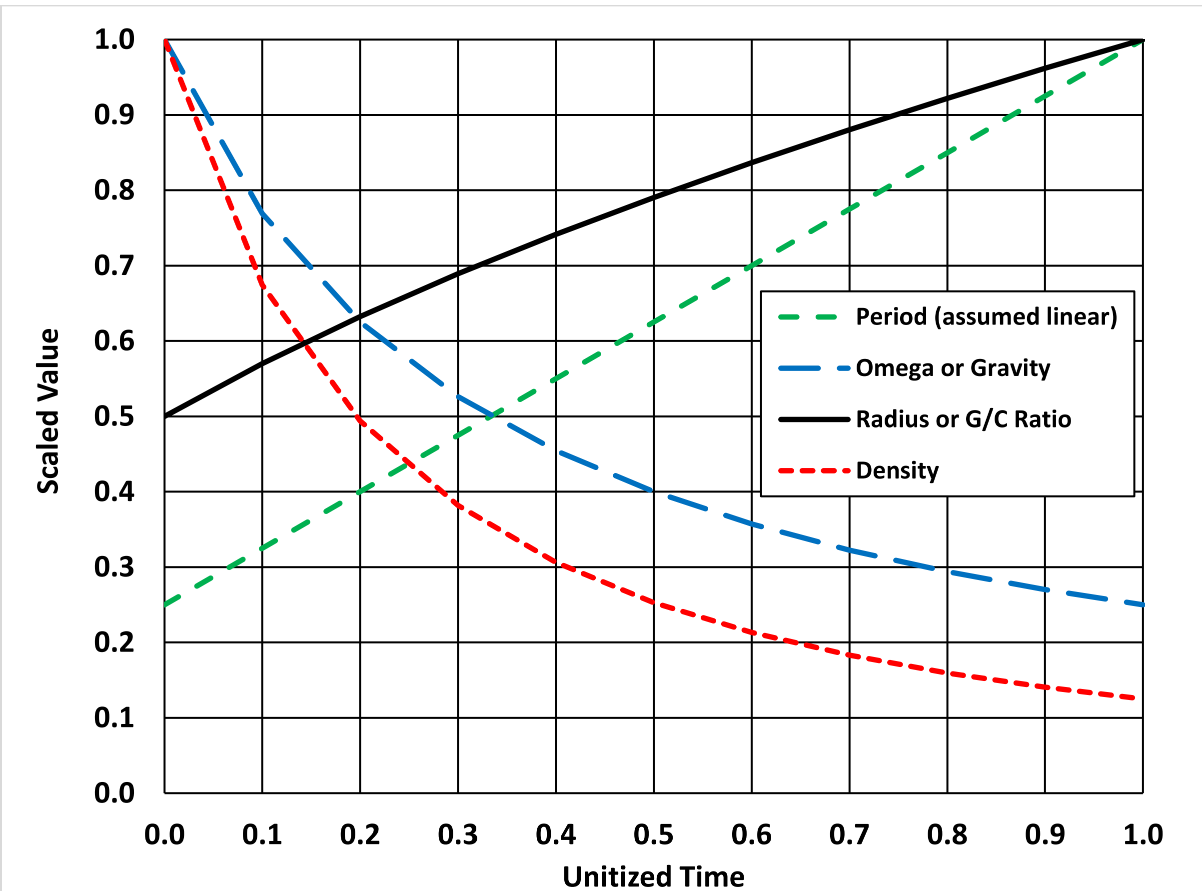
[5] Some, if not most, of today's water could have been acquired as the Earth expanded via collisions with water-laden astronomical bodies such as asteroids, especially during the alleged "Heavy Bombardment" era when the solar system was quite young.

[6] More accurately considered an inertial, "fictitious," or "pseudo" force. [10]

Time	Period (h)	Omega (rad/h)	Radius (km)	Density (kg/km^3)	Gravity (nt)	Centrifugal (nt)	Γ/C Ratio	Scaled Ratio
0.0	6.0	1.047	3200	4.37E+13	39.10	0.2708	144	0.500
0.1	7.8	0.806	3649	2.95E+13	30.08	0.1827	165	0.570
0.2	9.6	0.654	4048	2.16E+13	24.44	0.1338	183	0.632
0.3	11.4	0.551	4411	1.67E+13	20.58	0.1034	199	0.689
0.4	13.2	0.476	4746	1.34E+13	17.77	0.0830	214	0.742
0.5	15.0	0.419	5060	1.11E+13	15.64	0.0685	228	0.791
0.6	16.8	0.374	5355	9.33E+12	13.97	0.0578	242	0.837
0.7	18.6	0.338	5634	8.01E+12	12.61	0.0496	254	0.880
0.8	20.4	0.308	5901	6.97E+12	11.50	0.0432	266	0.922
0.9	22.2	0.283	6155	6.14E+12	10.57	0.0380	278	0.962
1.0	24.0	0.262	6400	5.46E+12	9.78	0.0338	289	1.000

What is of particular interest is the ratio of the gravitational to the centrifugal force at the equator as the Earth expands – this ratio experiences a doubling over the total time duration, but clearly shows the dominance of gravity by over a factor of 100. If each of the parameters is scaled to its maximum value, their relative behavior with time is shown below.



The expanding Earth with constant mass experiences four-fold decreases in rotational speed and surface gravity and eight-fold in density over the time duration, with the rates of decrease diminishing with time. Both the radius and ratio of the gravitational to centrifugal force at the equator double, with the rate of increase slightly diminishing with time. This suggests the following as a possible expansion mechanism. Relative to today, the early Earth's ratio of gravitational to centrifugal force was less, enabling an expansion due to the much higher rotational speed, gradually diminishing with time as the gravitational-to-centrifugal ratio grew.[7] If the early Earth started as a "sponge," perhaps this lower gravitational-to-centrifugal ratio resulted in an expulsion of water contained within the Earth, this rate of expulsion decreasing with time until today we have one-third of the Earth's water as oceans and the remaining two-thirds still within the Earth. This would account both for the spreading of the surface and filling of the volumes between the continents with ocean water. For the "waterworld" version of the early Earth, the initially rapid decrease in density, with this rate diminishing with time, would have enabled the Earth to absorb its surface water until only one-third remains today as the surface oceans.

4. Summary

In the "sponge" scenario, it was the initially higher relative ratio of centrifugal to gravitational force that enabled water to be expelled to the surface, thereby "drying out" the Earth's interior somewhat. In the "waterworld" scenario, it was the initially rapid decrease in density the led to absorption of the surface water, thereby "wetting" the Earth's interior. All this is, of course, quite speculative and a bit too convenient in that it allows for an explanation of either the "sponge" or "waterworld" scenario for an expanding Earth that has reached its present configuration. Nonetheless, given how speculative is the entire field of Expansion Tectonics, these suppositions can at least be viewed as additional "food for thought."

References

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Appendix: Effect of Latitudinal Variation

The following figure shows the gravitational and centrifugal forces at the Earth's surface at any latitude. While the centrifugal force is always directed perpendicularly to the axis of rotation, the gravitational is always radially inward toward the Earth's center. At a latitude of θ, the gravitational force on a 1 kg mass in the axis direction is $\Gamma \cos\theta$, opposite to the centrifugal force away from the axis, $\omega^2 R \cos\theta$. The ratio of the gravitational to the centrifugal force is then the same as at the equator, $\Gamma/\omega^2 R$, since the cos θ factors cancel out. Therefore, while the net force, $\Gamma - C$, decreases with latitude as the cos θ, the ratio remains constant. The decrease in the net force perpendicular to the axis of rotation with latitude would suggest a

[7] Not to be lost is the fact that the gravitational force still greatly dominates over the centrifugal, even at the earliest time when the Earth's radius was only half its current value. This may be the primary explanation for essentially no deviation from a spherical shape as the Earth expanded.

tendency for the rotating Earth to "elongate" more at the lower latitudes into an ellipsoidal shape. However, given the overwhelming strength of the gravitational force vs. the centrifugal and its radially inward direction, the Earth should maintain its spherical shape even as it "expands." Of course, this still assumes that, even though overwhelmed by gravity, the centrifugal force somehow contributes to Earth's expansion.