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Review Article

Consequences of Evolutionary Sea-Level Changes

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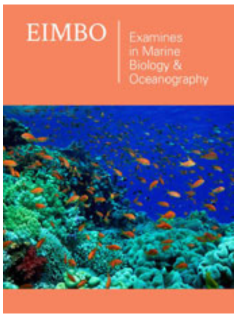
ISSN: 2578-031X



Abstract

Photoionisation of water generates reactive hydrogen ions and other light gases that escape to outer space by different mechanisms. The activity of the young Sun directed the lost light gases, primarily hydrogen and helium, to the outer gas giant planets. The total hydrogen loss on Earth in the past ~4 billion yearsunder the conditions that exist today showed that the H escape would have resulted in only about 0.02% loss of the recent ocean volume. The reason for this negligible loss could be the feeble rate of hydrogen escape by photolysis of water, but the Archean rate could have been much greater. Other suspected pathways for water losses could be the subduction of hydrate minerals or the increased amount of storage of water in the deeper layers of the mantle. Water loss is also accounted for by photosynthesis where water is photohydrolysed to oxygen and hydrogen and carbon dioxide reduced to carbohydrates. This study estimates the global loss of water based on the sinking generated low by converting them to sea volumes, indicating a significant (22%) loss of freshwater on Earth during evolution.

Keywords: Assessing sea volume; Evolutionary high sea-levels; Conversion of sea-levels and volumes; Osmolyte systems; Reasons of salination; Faltering thermohaline circulation

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Submission: August 11, 2021

Published: September 22, 2021

Volume 4 - Issue 2

How to cite this article: Gaspar Banfalvi. Consequences of Evolutionary Sea-Level Changes. Examines Mar Biol Oceanogr. 4(2). EIMBO. 000585. 2021. DOI: 10.31031/EIMBO.2021.04.0005845

Introduction

Table 1: Volumetric data of water on Earth.

S. No.	Volume of	Volume x $10^6 km^3$	Volume(%)	References
1	*Sea	1332.4	96.9	[27]
		1332.9	96.9	[29]
		1335	97.1	[35]
		1335	97.1	[36]
2	**Sea(average)	1333.8	97.0	-
3	†Freshwater in reservoir	25.54	1.86	[36]
4	‡Freshwater in land	15.66	1.14	[36]
5	Freshwater total	41.20	3.00	[36]
6	Water on Earth(#2+#5)	1376.2	100	[36]
7	Infant Sea (relat. to #2)	1681.1	126	[29]
8	Global loss of water(#7-#6)	305	-22	This estimate

*Sea volume, the average of four estimates rounded up to 1335x10^6 km^3(70.015%).

†Freshwater reservoirs: Ice, glaciers, permanent snow.

‡Freshwater inland: Lakes, artificial lakes, ponds, streams, wetland and groundwater.

Magmatic outgassing is thought to have shaped the Earth's Archean atmosphere. The ‚degassing' of steam by Earth's molten rocks could have led to the evolution of the original ocean. The rain continued to fall once the temperature dropped below boiling, and the ancient ocean was born. According to new studies, hydrogen in the Earth's interior could have a significant impact [1]. Asteroids could have carried water to the young Earth, during our planet's early years, among other possible sources [2]. The moon-forming impact of some

4,500Mya vaporized a substantial part of Earth's crust and upper mantle, disrupting the increase of water in the Earth's atmosphere around our young planet [3]. An earlier estimate showed that the global water supply of the Earth is about 1,338,000,000km^3 [4]. Other estimates are summarized and will be discussed in Table 1. As far as the osmolarity of the dilute Archean ocean is concerned, it was much lower than today and was driven by the volume of the water and its composition. The recent atmospheric escape of hydrogen on Earth is approximately 3kg/s loss of hydrogen and about 50g/s helium [5-7]. The escape velocity of hydrogen to outer space is the highest among light gases followed by helium, ammonia and water vapour and is dependent on gravity, which in the smaller inner planets of our solar system is lowest on Venus followed by Earth and Mars. The abundant CH_4 originating from methanogenesis could have contributed to the escape of light gases.

The isotopic ratios of heavier noble gases in the modern atmosphere suggest that heavier elements in the early atmosphere were also subject to significant losses [8]. The escape of gases is also dependent on the temperature, rate of cooling, greenhouse effect. The recent tendency suggests that the Sun will be brighter and hotter and in about 1 billion years the Earth will lose its water [9]. Similarly to what already happened to Venus.The shrinkage of freshwater reservoirs includesatmospheric moisture (snow, rain, clouds) and ice (glaciers, polar ice, ice sheets, permanent snow) contributed by the freshwater loss of global warming.

O_2 produced initially by the photosynthesis of cyanobacteria was originallyabsorbed bythe seabed rocks and started to rise in the shallow ocean approximately 2,400-2,000Mya [10]. Oxygen gazed out to the atmosphere when the ocean became saturated with oxygen about 1.85 billion years ago (Bya) and was taken upinitially mainly by land surfaces. Earth's atmosphere changed from a weakly reducing to an oxidizing atmosphere [11-13].

Due to its higher gravity and molecular mass, only small quantities of oxygen were found to escape to the Moon from the Earth [14]. The air in Earth atmosphere contains now 21 percent oxygen. The rise of oxygen concentration in the atmosphere is speeding up the oxidation process of the soil and rocksevidenced by satellite pictures showing the spread of expanding red patches of the globe especially at locations of water shortages (deserts, rocky mountains). An important warning signal of freshwater shortage is the increasing gap between the volume of saltwater versusfreshwater, which is now 97 to 3%, respectively. The question is how this ratio could have changed from a dilute solution to a salty osmolyte during evolution. Calculations predicted that the oceans of Archean Earth were up to 26% more voluminous than today and the Sun's brightness may have been as little as 70% of what it is today [15,16] keeping the Earth surface frozen much of its early history, which was not the case but remained a puzzle. To resolve the Early Sun paradox and moderating surface temperature in the Archaean aeon [17] suggested that the lower albedo of the early Earth provided environmental conditions above the freezing point of water.

Global glaciation was speculated by Douglas Mawson based on the mistaken assumption that glacial deposits found at low latitudes remained constant through time [18]. The ideaof global-scale glaciation reemerged with the advancement of the continental drift hypothesis, and plate tectonic theory, explaining why glaciogenic sediments were found at places where deposition took place on continents at higher latitudes [19]. An equilibrium was anticipated in which the incoming solar radiation absorbed by the Earth's system is balanced by the energy re-radiated to space as thermal energy increased reflectiveness (albedo) causing further cooling and the formation of more ice that stabilized a permanent ice-covered equilibrium [20]. To bypass such avicious feedback loopanother energy-balance model contained three stable global climates zones (tropical, temperate, polar). One of the polar climates was the snowball Earth [21]. Ice ages generated low sea levels particularly during the Proterozoic Snowball Earth period when Earth's surface became almost entirely frozen and covered by ice, snow and slush [22-24]. Substantial freshwater reservoirs were built up in the Proterozoic aeon (700-550Mya) [12,24,25]. Severe glaciations with low sea levels were followed by high sea levels (at or above 300m) example during the Paleozoic era at the end of the Ordovician period ~450 million years ago (Mya). Although the Ordovician lasted for only 45 million years and represented only ~1% of the age of the Earth, Life during this time diversified extremely fast. The unprecedented radiation of species in Ordovician could have been accounted for by the dilute, yet optimal osmolarity of the sea (0.2-0.4Osm) providing favourable conditions for thesynthesis of informational macromolecules (DNA, RNA, protein) in a cool and well-oxygenated ocean and under abundant fresh water supply. As gas escape theories did not provide reliable means to judge the global loss of water on Earth, our attention turned toward

A. Assessing the recent volume of the sea

B. Comparing sea levels at different geological ages

C. Converting sea levels into volumetric data and

D. Estimating the global loss of freshwater.

Assessing the Volume of Ocean

John Murray [26] was the first who utilised a simple model and measured the depth of the ocean at several locations then calculated the ocean volume by only 1.2% higher than the current estimates of the world's oceans [27]. Our data show a close relationship between sea-level rises and volumetric changes in the sea. These data were extended to a straight line and then extending the calibration curve (Figure 1) to higher sea levels. The different techniques used to measure changes in sea level do not measure the same level. Techniques termed tide gauges measure relative sea levels, whereas satellites measure absolute sea-level changes [28-30]. The sea volume measured by John Murray is close to the authoritative value (1332.4x10^6 km^3) measured more than 120 years later [27] and 0.4% lowerthan the value estimated by [4]. Estimates older than 30-40 years turned out to be higher than the recent satellite measurements [31]. Thus we have used volumetric measurements that are not older than 10 years.The earlier higher values could be accounted for by undersea mountains, ocean ridges and other geographical features that were not subtracted from the bulk of the ocean. Undersea features include continental shelves, slopes, rises, insular shelves that surround continents and islands, as well as zones of the ocean floor (continental margins, deep-ocean basins, mid-ocean ridges, sediments). The high sea levels and corresponding sea volumes during evolution were utilized to calculate the global loss of water on Earth.

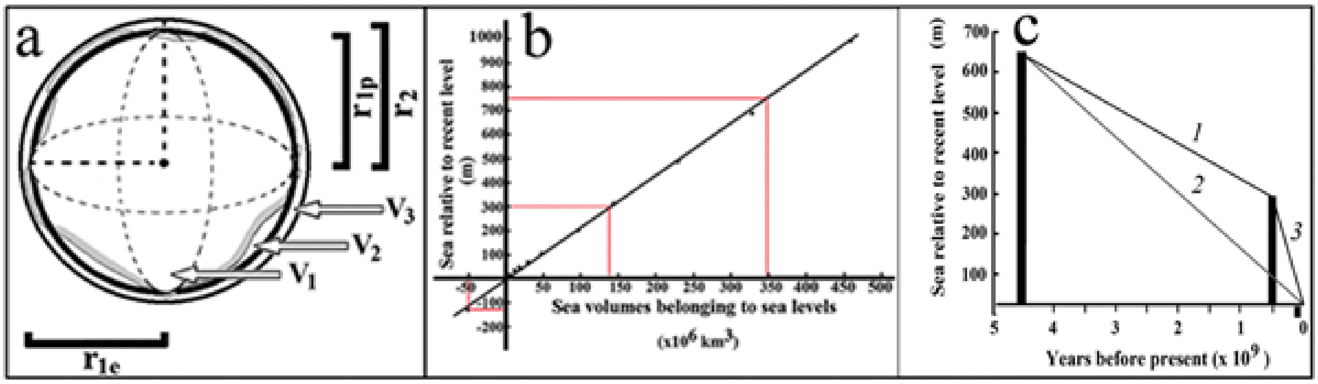

Figure 1: (a) Global sea levels and volumes (b) Plotting into a calibration curve (c) Evolutionary sea-level changes.

Calculations of Sea levels and Volumes

Calculations to test and validatedata included

The average radius (r_1) of the Earth from geometric radii. r_1 : 6367.3km [28].

A. Average sea depth, r_2: radius of Earth+depth of the sea (6,371,008m). The average of the polar and equatorial radius was taken as the sea depth. Ocean depth is divided into littoral, bathyal, abyssal and hadal zones. Accuracy is further impaired that only ~10% of the seafloor has been mapped.

B. Interconversion of sea levels and volumetric valuesinto each other.

C. Plotting evolutionary high and low sea levels and volumes into a calibration curve.

D. Calculations to test whether sea levels and volumes fit the calibration curve. Plotting three reference points of geological high sea levels and volumes rather than the previously used two points [29] resulted in an extended calibration curve including the highest sea level that existed at the time of the Infant Earth.

Evolutionary Changes in Sea levels and Volumes

Evolutionary changes in sea levels and their converted data to sea volumes were used to calculate the loss of freshwater on Earth. In ice ages, the volume of freshwater in the form of ice, snow, glaciers increased and could be judged by the thickness of ice, snow, etc. During interglacial periods the melting of ice took place and the increase of sea volume caused sea level rises. As the osmolarity of the sea increased, less and less water evaporated whereas the ratio of the freshwater decreased relative to thesalinating sea.

The extension of the calibration curve included the highest known sea volume of the Infant Earth that could have corresponded to an ~650m elevation relative to the recent sea level (6,371,008m). Compared to the average radius of the Globe (6,367.3km), the average depth of the sea (3,682.2m) is negligible thus the linearity of the calibration curve could not bedoubted (Figure 1).

A. Radii are used for the calculation of sea volumes, and underwater features. r_1: Earth radius: Average of equatorial (r_{1e}) and and r_{1p}polar radius (r_{1p}) of geoid Earth: 6367.3km [29]. Earth is not round, shown by the "potato-shaped" grey line. r_2=volumetric radius: radius of Earth+depth of sea: 371.008 km [31]; NASA: 6371.0 km [32,33]. V_1=volume of Earth calculated from r_1: 1,083.21x10^9km^3. V_2=volume of sea: 1332.9x10^6km^3 [29]. V_3 =actual volume arising from sea-level elevation.

B. Relationship between sea level elevations and sea volumes relative to recent data. The data of abscissa represent eustatic sea-level elevations and those of the ordinate the volumetric changes relative to recent data. Black points of the calibration curve indicate calculated sea volumes belonging to corresponding sea levels.

C. Evolutionary sea-level changes: The highest sea level of the Infant Earth was some 4.5Bya, the second highest Ordovicianhigh sea level (~300m) ~450Mya. The lowest sea level (-130m) relative to the recent level reached in the Eemian ~20,000 years ago during the Last Glacial Maximum (LGM) [28]. Despite the sea level fluctuations, the reduction of the three evolutionary highsea levels mentioned can be observed in the decreasing lines of (Figure 1c). Modified with permission [29].

Table 1 shows the recent volumetric data of water on Earth. The continental margin is constituting about 28% of the oceanic area [34]. All underwater features represent an estimated 29.5% of sea volume and will be more precisely determined as the measurements will become more accurate. Even the most reliable data obtained by satellite measurements of sea surface face some light reflection problems [27]. The resolution of the sea depth needs further fine-tuning by ship-based echo sonar and other methods. Satellite measurements show that the average ocean depth is 3,682.2m. This value multiplied by the area of sea (361.84x10^{6}km^3) results in the volume of the ocean of 1,332.4x10^{6}km^3 [27]. These measurements show a perfect match (±0.1%) with other values published within the last ten years (Table 1).

Estimation of Waterloss During Evolution

Estimation of the global loss of water was by subtracting the recent volume of the sea from the volume belonging to the highest sea level.

A. The volume of the globe: represented by the volume of Earth+the volume of the sea.

B. Calculated from $r_{2:}$ 6,371,008m → 1,083.210 x 10^{9}km^3.

C. The volume of underwater features

D. Substraction of volumes calculated from r_2 minus r_1:

E. 1,083.210x10^{9}km^3-1,081.320x10^{9}km^3 → 557x10^{6}km^3 (29.5%)

F. Volume of sea 1332.9 x10^{6}km^3 [29] (70.5%)

G. Underwater features: 557x10^{6}km^3 (29.5%)

Total volume of water on Earth (sea+underwater features): 1889.9x10^{9}km^3(100%). Calculations revealed that the volume of the underwater features represent only a small portion of the ocean, confirming that the average seabed (ocean floor) is a relatively flat surface despite the presence of deeper geologic subductions such as the Mariana Trench. An explanation to the flat surface of the seabed could be that the sedimentation of insoluble particles smoothens the surface. The elevations of sea-level rise originate mainly from the melting of freshwater reservoirs and to a much lesser extent from the thermal expansion during interglacial periods. Predictions forecasted that the recent interglacial period could melt about 80% of the Earth's ice and snow reserves of ~50x10^6 km^3 [31-37]. Others judged that the freshwater reserve is only about half (~24x10^6 km^3) of this estimation [4]. A newer estimate shows a somewhat higher freshwater reserve (25.54x10^6 km^3) [35] that is only about half of the maximum of the latest ice age some 120,000 years ago. The advantage of the calibration curve (Figure 1b) is that sea levels can be turned into volumetric values and vice versa. More importantly, utilizing the calibration curve one can estimate the global water loss.

The highest reported sea level was at the period of the Infant Earth [15,17]. To judge the global loss of freshwater, the highest sea-level rise of the Infant Earth served as a basis. This sea-level could have been higher than it is today up to 650m (Figure 1b) corresponding to a sea volume of ~1,681 x 10^6 km^3. Volumetric data of sea and freshwater are summarised in Table 1. The calibration curve (Figure 1b) takes into consideration that in the presence of continental crust, the sea level is about 29.5% higher than in its absence. Due to the lack of landmasses, the early Earth was assumed to be completely covered with water [17] but could have already contained some underwater features.

Ocean as a Global Osmolyte System

Despite large sea-level fluctuations, only small changes can be traced if at all, leading to the conclusion that in general, the rate of salt input and output in the sea was nearly equal in agreement with the long-term mean of salinity of the ocean [15]. The false idea of a general geochemical balance of the sea is related to the limited judgement of man that does not extend to more than four human generations (~100 years). Such a period is too short to notice any change, nevertheless provided a model to make constancy plausible [38,39]. The view of a dynamic osmolyte rather than a steady-state ocean system suggested short-term volumetric decreases during ice ages; sea level rises during interglacial periods and long-term salination of the ocean [29,40,41].

When discussing osmolytes one cannot escape the thought that living cells consuming and producing substances in a dilute aqueous milieu, resemble the ultimate dilute solution, the primordial ocean. The idea that the nearly uniform osmolarity of the blood of land vertebrates reflects the osmolarity of an ancient stage, namely the concentration of the primordial ocean at the time of migration to land is not new [42-45]. There is a consensus that extracellular and intracellular salt concentrations of living organisms were identical and vertebrates remained in osmotic equilibrium with the sea before they moved to land during the Devonian Era some 450Mya[46-50]. This view needs to be reconciled with the fact that the osmotic concentration of sea water (1.09 Osm, 3.5% Nacl) is now more than three times higher than the isotonic concentration of the blood of land vertebrates. As the osmolarity of the present-day ocean is 1.09Osm, whereas the osmolarity of blood serum of land vertebrates remained nearly constant (~0.3Osm). A corollary of the dynamic ocean hypothesis is that the salinity of oceans is gradually increasing [51-59]. Salinity changes of the sea over geological ages provide evidence for a dynamic osmolytesystem against a persisting general geochemical balance. The uniform osmolarity of blood in land vertebrates (300 ± 15 mOsm) with the notable exception of amphibians (160-240 mOsm) is a reflection of the osmolarity of seawater at the time of their evolutionary emergence from the marine environment. The stability of the inner environment of land vertebrates is an indication that the concentration process could have taken place in the sea over the past hundred million years [59]. Among the major factors causing the salination of oceans, several processes could have been involved.

Salination and Dilution Processes

Salination processes

Ice formation: In polar regions and mountains snow and ice, formation causes solvent deficiency and contributes to the salination of oceans. During the advances of ice ages, the sea level decreased significantly which in turn increased the salinity of the sea. Based on Charles' law the cooling effect of ice ages lowered the temperature of the sea further decreasing its volume and increasing the salt concentration. Lowered water temperature increased the solubility of oxygen, which in turn stimulated aqueous life.

Continental drift and outpouring lava: The constant renewal of the seafloor causes constant and immense pollution and increases the salt content of the sea. The upper part of the crust is formed from episodic extrusions and intrusions of basaltic melt. The lower crust is formed by rapid hydrothermal alterations of the mantle [46]. The volcanic gases (CO_2, H_2S, HCl, HCN, SO_2) and the soluble salts of the new crustal material of the erupting lava are dissolved pollutants of the ocean.

Weathering and denudation: These processes carry away the surface waste of land, especially if not protected by forests. Endogenic processes (volcanos, earthquakes, plate tectonic uplifts) also expose the continental crust to exogenic denudation processes of weathering and erosion. Mass wasting is increasingly contributed by man. Most of the salt of the eroded surface of the soil and sand especially that of spreading deserts is deposited in the ocean as sedimentary rocks the salt content of which increases the salinity of the sea. From an osmotic point of view, only the number of dissolved particles matter irrespective of the quality of the salinating waste.

Hydrologic cycle: This cycle consists of evaporation from the sea, evapotranspiration from soil and vegetation and precipitation. One pathway is the backflow of freshwater bodies to sea carrying diluted dissolved salt constantly in small concentrations (<0.1%). The ”salt clock” methodof Joly (1899) served to determine the age of Earth based on the continuous salinity intake of the ocean by the water cycle [47]. Although, the ”salt clock” method did not work but led to the recognition that salination is a long-lasting process [47-49]. The effect of the hydrologic cycle is strengthened by the chemical pollution of rivers, which has already been noticed eg in Amazonia due to the mining on an industrial scale, forest burning and uncontrolled use of pesticides [50].

Sea-level regression: There is clear evidence that the sea level was lower in the final stage of the Cretaceous by more than at any other time in the Mesozoic Era, but there is no direct evidence for the cause of this regression. One explanation for this phenomenon could be that the mid-ocean ridges could have sunk under their weight [51]. Such a severe regression could have resulted in a virtual loss of sea. Another explanation for this phenomenon could be that the higher salt content of the ridges could have increased the salinity of the sea. Other disturbances responsible for the sea to sea variations in chemical composition, even if small, may cause significant global climatic changes, the consequences of which may not all be known. A possible explanation could be that the regression of sea level was not a virtual but a real loss of sea volume. The global aspects of the ocean as an osmolyte system favours the long term global loss of water and the related salination of the sea [52].

Seawater reverse osmosis: One would expect that desalination of the ocean to obtain freshwater would significantly increase the salinity of the sea. Reverse osmosis is a desalination membrane process based on semi-permeable membranes that have been commercially used since the 1970 [53]. The volume of desalinated water is 10^9 times less than the volume of the ocean and under recent proportions does not represent a real threat to ocean salinity. In fact, the most important waste management program of reduction of the CO_2 burden could be the use of nuclear energy, solar energy, geothermal energy, tidal power, wave power of ocean surface waves and wind power that could serve not only the supply of clean electric electricity but also the removal of salt from the sea by desalination in huge quantities and pumping freshwaters into reservoirs.

River pollution and dumping of contaminated wastes: The danger of river pollution and ocean dumping has been recognized and banned worldwide, but the prohibition has not been executed. As already referred to it, irrespective of the origin of the waste, it contributes to salination, increases osmosis, lowers the rate of evaporation and precipitation.

Pollution of sea: Similarly to freshwater contamination, the pollution of the sea is not the focus of this study and will be only briefly discussed. Convincing evidence was presented that tropical waters became saltier over the past 40 years, despite polar seas injected immense amount of fresh water into the ocean [54,55] temporarily and locally lowering its salinity. Despite of local chemical pollutions, the mean ocean salinity has not much changed. For this latent constancy, the mass action law gives a reasonable explanation. The mass of the ocean weighs 270 timesmore than the atmosphere (1.38×10^{21} kg/5.1×10^{18} kg = 270). Consequently, it will probably take an even longer time to acknowledge the global salinity increase than the recognition ofair pollution and global warming took and became measurable only at the last century. Further large scale salinity changes candisrupt the thermohaline circulation, a possibility that has to be considered by the sea surface salinity programs. These programs are being executed by the European and American Space Agencies. Besides refining data of local changes in the open ocean, these measurements also clarify several phenomena of the water cycle and ocean circulation, representing the two major components that regulate the climate system of Earth.Less attention was paid to the thermal expansion of water that may modulate sea levels and volumes similarly to gravitational, volcanic, polar winds, radioactive processes, etc. but probably do not significantly influence them, whereas their biological impact may be significant especially in transition periods. The recent small thermal expansion of sea volume is a reflection of a short term dilution period, that temporarily compensates and surpasses the long-term salination of the sea.

Dilution processes

Besides the several processes involved in Salination we have also to consider the opposite global dilution process.

Evaporite deposits: Rising Seabed’s cause obstruction, limited flow, loss of contact of inner shallow seas to the ocean. Evaporite deposits could have temporarily decreased ocean salinity [56-58]. In agreement with the opinion of Holland [11] the salt extraction probably did not decrease significantly the global salinity of sea.

Dilution by thermal expansion: Water expands at higher temperatures and contracts as it is warmed up from 0 to 4 °C. The average deep-sea temperature is 2 °C, with an average sea surface temperature of 17 °C. Assuming an average 2 °C deep-sea increase (from 2 to 4 °C) of global sea temperature the volumetric contraction would still be negligible, and the expansion would be within a few percentages. By eliminating the negligible changes of thermal expansion and contraction of seawater, the recent global melting remains to be restricted to the availability of the freshwater reserve with its modest (2%) dilution effect on the World Ocean.

Faltering of thermohaline circulation: The biggest threat of large and rapid salinity changes could be the disruption of the Thermohaline Circulation (Figure 2), a possibility to be considered by the sea surface salinity (SSS) programs. These programs are mainly executed by the European Space Administration (ESA), by the Aquarius/SAC-D mission of NASA and by the Space Agency of Argentina (Comisión Nacional de Actividades Espaciales, CONAE). The surface water of the ocean current brings warm water from the South Atlantic via the Gulf Stream to the North Atlantic ocean and keeps the regions around Island and southern Greenland free of ice. The Nort Atlantic Current originates from where the Gulf stream turns north at the Southeast Newfoundland submarine ridge stretching the Grand Banks of New foundland. The North Atlantic Current is supplied primarily by subpolar waters, including the cooler Labrador current that is recirculated into the North Atlantic Current. The North Pacific current is a slow warm water current that flows west-to-east between 30 and 50 degrees north in the Pacific Ocean and forms the southern part of the North Pacific Subpolar Gyre and the northern part of the North Pacific Subtropical Gyre. Figure 2 sea surface salinity, temperature and evaporation. (a) False-colour composite of global distribution of sea surface salinity and representation of the thermohaline circulation. Sea surface salinity generally ranges between 3.3 and 3.7% in the open ocean [59,60]. The Great Ocean Conveyer shows the recent global thermohaline circulation. Combination of the annual mean sea surface salinity data obtained from the World Ocean Atlas [60] and thermohaline circulation [61]. (b)Sea surface temperature during the first week of February 2011 at the 180th meridian (Date Line) passing through Russia, Fiji and Antarctica [62,63]. (c)Water cycle with warm (low density), cool (medium) and cold (higher density) stratification of seawater. Arrows in the upper right corner refer to the leakage from the upper atmosphere to the space. Ruptures in the Great Ocean Conveyor Belt could weaken the thermohaline circulation. It is suspected that weakening of the subpolar gyres and/or accumulation of the cold deep water of higher salinity could be related to climate change and explain recent heatwaves at several locations in the southwestern part of Canada, and eight US states had their hottest June in the Pacific Northwest. Heatwaves have increased in intensity, frequency and duration across Australia over the past seven decades [59]. The weakening of the Golf current could have resulted in the storm named Filonema with heavy snow and plunging temperatures in Spain with the temperature plunging to -8 °C while in Greece the temperature remained unusually warm.

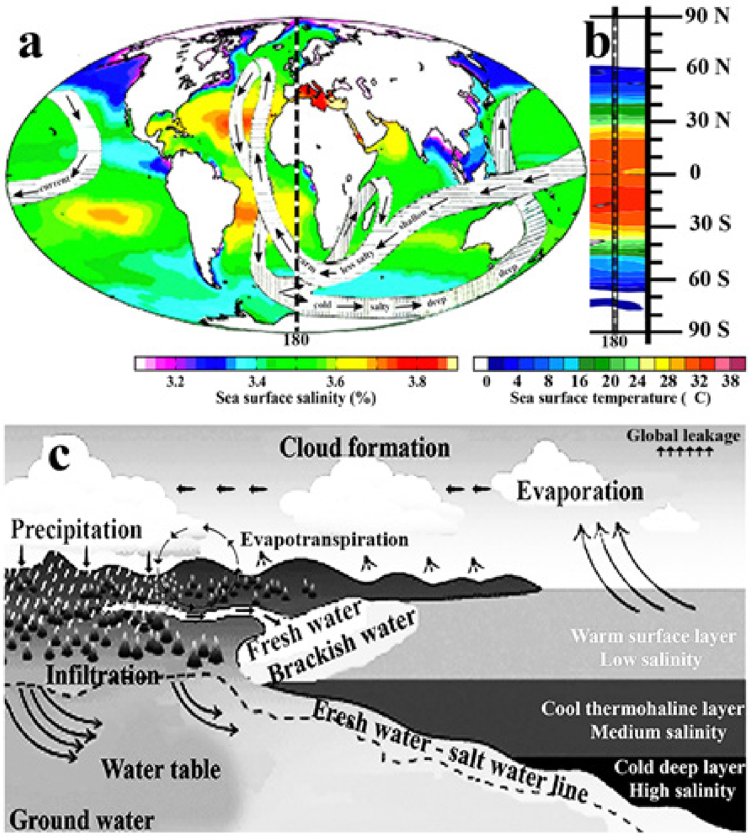

Figure 2: Sea surface salinity, temperature and evaporation.

Evaporation Over Oceans

Nearly 80% of water evaporation occurs from the oceans, with the rest of 20% coming from inland water and vegetation. The wind is carrying the evaporated water around the globe, distributing the humidity of air throughout the world. Water vapour exists mainly as water gas outside the clouds and is more intense at warmer temperatures and during interglacial periods than in cold weather and ice ages. The increasing salinity of the sea reduces the rate of evaporation, cloud formation and precipitation in accordance with the law of dilute solutions.

Discussion

One of the possible explanations for the global freshwater loss was that water vapour at the upper atmosphere photohydrolysed to H and oxygen. Oxygen and water group species could have escaped to space by the polar wind, photoionisation generated reactive hydrogen ions and other light gases could have escaped to the outer space by different mechanisms. Our calculations showed that the escape of hydrogen to space was less than 0.02% indicating that the recent rate of hydrogen escape to space could not have caused significant water loss. Alternatively, sea levels and sea volumes were used to calculate the loss of water on Earth. Data obtained by the calculations presented in this study correspond to the results obtained by others [36,64]. From evolutionary high sea levels, the volumes of the sea were calculated and a calibration curve was plotted. Employing the calibration curve:

A. Sea levels and be converted to volumes and vice versa.

B. The 26% more voluminous Infant Sea [15,17] was about 650m higher than it is today.

C. The Recent volume of the sea is: $1332.9x10^6km^3$ (70.5%).

D. The Volume of underwater features without the continental shelf is $557x10^6km^3$ (29.5%).

E. The continental sea shelf is the shallow seafloor, generally less than 200m in water depth, which is surrounding continents and islands.The continental shelf covers an area of about 27 millionkm^2, equal to ~7% of the surface area and $5.4x10^6km^3$ of the oceans (continental -defined by IHO in 2008) as “a zone adjacent to a continent” (or around an island) and extending from the low water line to a depth at which there is usually a marked increase of slope towards oceanic depths.

F. Data confirm the close relationship between sea-level rises and volumetric changes of the sea as well as evolutionary reduced sea level highs and global loss of water.

The consequences of sea-level changes suggest decreasing degreesof fluctuationsof sea levels explainable by the gradual loss of water on Earth, the shortage of freshwater worldwide and the long-term salination of sea. Applying Raoult’s law to the sea as a global osmolyte system, the salination process gradually decreases the frequency of evaporation of water vapour resulting in less precipitate and freshwater.

Consequences of Freshwater Loss

Characteristic biological phenomena accompany the loss of freshwater. Although the decreasing tendency of recent sea-level rises will not significantly reduce the salinity of the sea, due to the recently available limited freshwater reserves, nevertheless its effect will severely impact the life in the continental sea-levels seashores including many large cities in harbours. The life of sea animals will be hardly affected, unlike land vertebrates, including the man that is entirely dependent on freshwater. The migration of people driven by the shrinkage of available freshwater and the groundwater is widely exploited when rates exceed its recharge from rain and rivers over longer periods and larger areas, called groundwater depletion [65-67].

Groundwater storage can recover only when pumping decreases or more groundwater is recharged from precipitation, rivers or engineered managed aquifer recharge (MAR) systems. The local groundwater depletion should not be confused with the global loss of water. Alternatively, the shortage could be explained by the water that supplies the intermediate layers of the mantle, whereas the core of the Earth is gradually cooling off. Due to the freshwater shortage, the habitat of species is decreasing at an alarming rate, threatening the extinction of many endangered freshwater species. The salinity of the ocean may have increased through time as Earth’s surface water inventory declined.An alternative explanation of the global loss of water (primarily freshwater) could be that as the inner part of our planet is cooling off, more and more water is taken up by the mantle, decreasing the sea level. Besides the Atlantic, Pacific, Indian, and Arctic Oceans, most countries-now recognize the Southern (Antarctic) as the fifth ocean. However, so far there has been no evidence provided that the sea level would have dropped due to the gradual trickling of water inside the core and outpouring of lava.

Conclusion

It is concluded that different sea levels with decreasing heights during evolution can be used to estimate the global loss of water at different ages. At the highest sea level, the Infant Earth could have been by 26% more voluminous than it is today. The second-largest sea levelrise (at or higher than 300m) took place during the Paleozoic era in the Devonian period some 450 Mya. Fluctuations indicate record-low sea level (-130m) about 20,000 years ago. The basis of estimation of the global loss of freshwater is the subtraction of the recent volume of the sea from the amount belonging to the highest sea level. The substantial freshwater shrinkage contributed by man and the salination of the sea demand counteractions to be taken or already in effect to protect life on Earth.

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Author Contribution

All activities related to the preparation and publication of the manuscript were carried out by a single author.

Acknowledgement

The calculation of water loss caused by the hydrogen escape to outer space is gratefully acknowledged to Prof. Henry Paulus. This work was supported by the OTKA grant T0 42762 to GB.

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