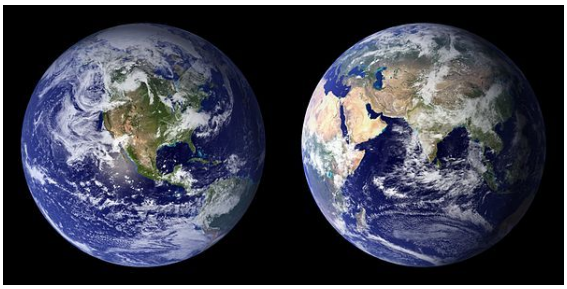
Origin of water on Earth



Water covers about 75% of the Earth's surface

The **origin of water on Earth**, or the reason that there is clearly more liquid water on the Earth than on the other rocky planets of the Solar System, is not completely understood. There exist numerous more or less mutually compatible hypotheses as to how water may have accumulated on the earth's surface over the past 4.6 billion years in sufficient quantity to form oceans.

1 Planetary cooling

- The cooling down of the primordial world to the point where the outgassed volatile components were held in an atmosphere of sufficient pressure for the stabilization and retention of liquid water.

2 Extraplanetary sources

- Comets, trans-Neptunian objects or water-rich meteoroids (protoplanets) from the outer reaches of the main asteroid belt colliding with the Earth may have brought water to the world's oceans. Measurements of the ratio of the hydrogen isotopes deuterium and protium point to asteroids, since similar percentage impurities in carbon-rich chondrites were found in oceanic water, whereas previous measurement of the isotopes' concentrations in comets and trans-Neptunian objects correspond only slightly to water on the Earth.

- Planetesimals heated by the decay of aluminium. This could cause water to rise to the surface[1]

That the Earth's water originated purely from comets is implausible, as a result of measurements of the isotope ratios of hydrogen in the four comets Halley, Hyakutake, Hale-Bopp, and 67P/Churyumov–Gerasimenko by researchers such as David Jewitt, as according to this research the ratio of deuterium to protium (D/H ratio) of the comets is approximately double that of oceanic water. What is however unclear is whether these comets are representative of those from the Kuiper Belt. According to A. Morbidelli [2] the largest part of today's water comes from protoplanets formed in the outer asteroid belt that plunged towards the Earth, as indicated by the D/H proportions in carbon-rich chondrites. The water in carbon-rich chondrites point to a similar D/H ratio as oceanic water. Nevertheless, mechanisms have been proposed[3] to suggest that the D/H-ratio of oceanic water may have increased significantly throughout Earth's history. Such a proposal is consistent with the possibility that a significant amount of the water on Earth was already present during the planet's early evolution.

Recent measurements of the chemical composition of Moon rocks suggest that Earth was born with its water already present. Investigating lunar samples carried to Earth by the Apollo 15 and 17 missions found a deuterium-to-hydrogen ratio that matched the isotopic ratio in carbonaceous chondrites. The ratio is also similar to that found in water on Earth. The findings suggest a common source of water for both objects. This supports a theory that Jupiter temporarily migrated into the inner Solar System, destabilizing the orbits of water-rich carbonaceous chondrites. As a result, some of the bodies could have fallen inwards and become part of the raw material for making Earth and its neighbors.[4] The discovery of water vapor out-gassing from Ceres provides related information on water-ice content of the asteroid belt.[5]

3 Hydrate minerals

- Gradual leakage of water stored in Hydrate minerals of the Earth's rocks.

4 Volcanic activity

Water may also have come from volcanism: water vapor originating in volcanic eruptions condensing and forming rain.

5 Water in the development of the Earth

See also: Planetary differentiation

A sizeable quantity of water would have been in the material which formed the Earth.[6][7] Water molecules would have escaped Earth's gravity more easily when it was less massive during its formation. Hydrogen and helium are expected to continually leak from the atmosphere, but the lack of denser noble gases in the modern atmosphere suggests that something disastrous happened to the early atmosphere.

Part of the young planet is theorized to have been disrupted by the impact which created the Moon, which should have caused melting of one or two large areas. Present composition does not match complete melting and it is hard to completely melt and mix huge rock masses.[8] However, a fair fraction of material should have been vaporized by this impact, creating a rock-vapor atmosphere around the young planet. The rock-vapor would have condensed within two thousand years, leaving behind hot volatiles which probably resulted in a heavy carbon dioxide atmosphere with hydrogen and water vapor. Liquid water oceans existed despite the surface temperature of 230 °C because of the atmospheric pressure of the heavy CO_2 atmosphere. As cooling continued, subduction and dissolving in ocean water removed most CO_2 from the atmosphere but levels oscillated wildly as new surface and mantle cycles appeared.[9]

Study of zircons has found that liquid water must have existed as long ago as 4.4 Ga, very soon after the formation of the Earth.[10][11][12] This requires the presence of an atmosphere. The Cool Early Earth theory covers a range from about 4.4 Ga to 4.0 Ga.

In fact, recent studies of zircons (in the fall of 2008) found in Australian Hadean rock hold minerals that point to the existence of plate tectonics as early as 4 billion years ago. If this holds true, the previous beliefs about the Hadean period are far from correct. That is, rather than a hot, molten surface and atmosphere full of carbon dioxide, the Earth's surface would be very much like it is today. The action of plate tectonics traps vast amounts of carbon dioxide, thereby eliminating the greenhouse effects and leading to a much cooler surface temperature and the formation of solid rock, and possibly even life.[13]

6 Role of organisms

Some terrestrial water may have had a bio-chemical origin, during the Great Oxygenation Event, via redox reactions and photosynthesis.[14]

In the early 1930s, Cornelis Van Niel discovered that sulfide-dependent chemoautotrophic bacteria (purple sulfur bacteria) fix carbon and synthesize water as a byproduct of a photosynthetic pathway using hydrogen sulfide and carbon dioxide:[15]

$$CO_2 + 2\,H_2S \rightarrow CH_2O + H_2O + 2\,S$$

Few organisms utilize this method of photosynthesis today, making their water contribution negligible. But on the hydrogen sulfide-rich and oxygen-poor early planet, a small but significant portion of the earth's water may have been synthesized biochemically through this pathway.

7 See also

- Water on terrestrial planets
- http://www.nature.com/news/earth-has-water-older-than-the-sun-1.16011

8 Notes

- Jörn Müller, Harald Lesch (2003): Woher kommt das Wasser der Erde? - Urgaswolke oder Meteoriten. Chemie in unserer Zeit 37(4), pg. 242 – 246, ISSN 0009-2851
- Parts of this article were translated from the original article from the German Wikipedia, on 4/3/06

9 References

[1] http://phys.org/news/2014-02-earth.html#jCp

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10 External links

- Dr. C's Oceans Online website (archived copy)
- UniverseToday.com

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