In the search for extraterrestrial life one of the key elements to look at when considering a potential planet is the presence of liquid water. Based on our current understanding of biology, life cannot exist without liquid water, so any planet that might have life on it must have liquid water. In April of 2013 NASA's Kepler mission discovered two planets, Kepler-62e and Kepler-62f, close to the same size as earth and in the Goldilocks zone[1]. The only difference is that these two planets are covered in water. Is it possible that life could evolve on these water worlds?

As stated above for life to exist it must have liquid water. At a basic understanding we know that animals and plants die during a drought, but out need for water goes much farther than that. Water is integral to how carbon dioxide cycles through the atmosphere[2]. The carbon dioxide cycle needs to remain in balance to prevent the planet from overheating due to heat trapped by a carbon dioxide rich atmosphere and to prevent the planet from freezing due to a carbon dioxide sparse atmosphere. The effect that a planet wide ocean would have on the carbon dioxide present in the atmosphere is to greatly narrow the habitable zone in which that planet can reside. The increase in water surface area would cause more wild fluctuations in carbon dioxide which in turn could cause wild fluctuations in surface temperature for the planet[3]. This would greatly reduce the habitable area in which such a planet can occur, but Kepler-62e and f are believed to have liquid water on them serving as evidence that they are the correct distance from their star. Life evolved on earth in a carbon dioxide rich atmosphere, in fact, life requires an oxygen sparse atmosphere to get started due to the reactive nature of oxygen[4]. Based on this it is entirely possible for life to have formed under Kepler-62e and f's atmosphere.

So far we know that Kepler-62e and f are not hostile to life, but that does not necessarily mean they have all the elements necessary for life to evolve spontaneously. Based on the RNA World Hypothesis, life requires amino acids and an inorganic structure to help slot the RNA chains together[5]. It has been experimentally shown that amino acids can form spontaneously under certain conditions. A mixture of water, ammonia, methane, and hydrogen was subjected to heat and electricity. After cooling the water contained basic amino acids[6]. The currently available data does not specify if Kepler-62e and f contain ammonia and methane but they are known to contain water and hydrogen. Both planets are covered in clouds which means that lightning would be present to provide the electricity needed and proves that a water cycle of heating and cooling exists. While this is not proof that an RNA world evolved on these planets, it is promising that they could contain the necessary conditions for it.

The second theory for the origin of life has it take place deep in the oceans of earth. Based on the Deep Sea Hydrothermal Vents Hypothesis life needs a proton gradient and a material suitable to form protocells. On earth these conditions could be found near hydrothermal vents. The proton gradient occurs where proton deficient sea water meets with proton rich fluid spouted by the vents and the material needed comes from the walls of the vent. Hydrothermal vents are just underwater fissures in the earth's crust so if tectonic activity exists on these underwater planets it is probable that

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1 Kaltenegger, L., Sasselov, D., & Rugheimer, S. (2013). Water-planets in the habitable zone: atmospheric chemistry, observable features, and the case of kepler-62 e and -62 f. The Astrophysical Journal, 775(2). doi:10.1088/2041-8205/775/2/l47

2 Schimel DS Braswell BH Parton WJ 1997 Equilibration of the terrestrial water, nitrogen, and carbon cycles. PNAS 94:8280–3.

3 Schimel DS Braswell BH Parton WJ 1997 Equilibration of the terrestrial water, nitrogen, and carbon cycles. PNAS 94:8280–3.

4 Lyons, T. W., Reinhard, C. T., & Planavsky, N. J. (2014). The rise of oxygen in Earth's early ocean and atmosphere. Nature, 506(7488), 307-315. doi:10.1038/nature13068

5 Harris, T. (2010). Evidence for RNA origins. Nature, 464(7288), 494-494. doi:10.1038/464494a

6 Saitta, A. M., & Saija, F. (2014). Miller experiments in atomistic computer simulations. Proceedings of the National Academy of Sciences, 111(38), 13768-13773. doi:10.1073/pnas.1402894111

hydrothermal vents exist. Presence of a magnetic field, which would definitively prove the presence of tectonic activity, was not published in NASA’s release on the Kepler-62 planets, but it is safe to assume that a planet of similar size and density as Earth would have a molten rock core. Both planets in question are roughly the same mass and volume as earth[7]. From this we can infer that these planets probably have tectonic activity. The presence of these vents is not enough to prove that a proton gradient exists since an acidic ocean is also required, but it does make the presence of life more probable.

Overall it is nearly impossible to prove that life exists on another planet, particularly because the nature of the origin of life is still somewhat in question. That being said Kepler-62e and f both show great promise. There is nothing that proves that life is impossible on these planets which is the best we’ve found so far. If life does exist on these planets it would be very different due to the lack of surface land and its probable that this live never evolved far enough to achieve interstellar communication. Fermi’s paradox aside, the discovery of these planets is very promising and leads the way to the discovery more planets of this type.

7 Kepler-62: A Five-Planet System with Planets of 1.4 and 1.6 Earth Radii in the Habitable Zone. (2013). Science, 340(6132), 587-590. doi: 10.1126/science.1234702