Ocean worlds may be dying stars' last haven for life

00:01 11 December 2008 by **David Shiga**
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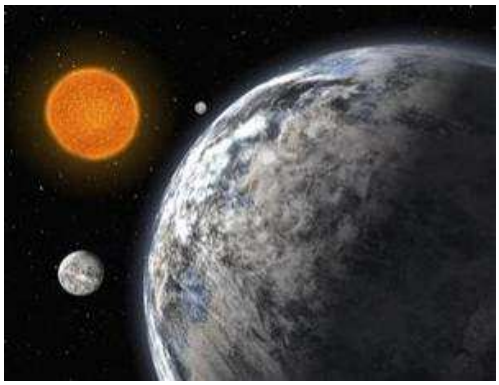
Large and distant ocean worlds could provide a last refuge for life around Sun-like stars, long after the heat of the stars' red giant phase sterilises closer-in, Earth-like planets, new calculations suggest.

Stars similar in mass to the Sun swell to become red giants at the end of their lives, engulfing their inner planets and roasting slightly more distant ones. The Sun itself is scheduled to enter this phase around 5 billion years from now, which should bake to death any remaining life here even before the planet is swallowed up altogether.

Far-sighted researchers have dreamed up outlandish schemes to allow future civilisations to move the Earth to a safe distance.



Distant, massive planets may still support life when their host stars become bloated red giants (Illustration: ESO)

But new calculations suggest life could naturally hang on in more remote locales around red giants, reinforcing similar results from an earlier but less detailed study.

The new study focuses on the conditions needed for photosynthesis, including an atmosphere with enough carbon dioxide to support the process, and a temperature that would allow liquid water to exist on the planet's surface. The study was led by Werner von Bloh of the Potsdam Institute for Climate Impact Research in Germany.

Warm cores

Life on planets the size of Earth would die off before the red giant phase begins, the team argues. That's because the planet's cooling core would stop the volcanic activity needed to replenish atmospheric carbon dioxide, which is gradually removed by the formation of carbon-containing rocks. Plants would thus run out of CO_2 needed for photosynthesis.

But the cores of bigger planets, called super-Earths, would stay warm for longer, allowing CO_2 to persist in their atmospheres. Recent discoveries suggest that super-Earths are common around other stars.

Those that start out farther from their parent star than Earth might be frozen during the star's youth and middle-age. But they would thaw out later, as the star's habitable zone - where temperatures are right for liquid water - moves outwards as the red giant phase progresses and the star's size and brightness grow.

Sweet spot

Where would a planet have to lie to enjoy habitable conditions for the longest amount of time during this process? Around a star with the Sun's mass, the 'sweet spot' would lie a little beyond the orbit of Mars, at around twice the Earth-Sun distance, the team says.

An ocean-dominated super-Earth would be best, because it would be best able to hold onto its CO_2 atmosphere, the team says. The reactions that convert CO_2 into carbon-containing rocks, and thus remove it from the atmosphere, require land exposed to air to function, so they slow down when exposed land is scarce.

A 10 Earth-mass planet at twice the Earth-Sun distance - whose surface was also 90% covered by water - would be in the red giant's habitable zone for 3.7 billion years, the team says. That's almost as long as life has existed on Earth, if the oldest and still controversial evidence is to be believed.

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Too hot?

A 2005 study led by Bruno Lopez of the Observatoire de la Cote d'Azur in Nice, France, came to similar conclusions about the habitability of relatively distant planets, but relied on older data on how Sun-like stars evolve, and did not investigate the role of planet mass and fraction of ocean coverage.

William Danchi of NASA's Goddard Space Flight Center in Greenbelt, Maryland, US, who was involved in the 2005 study but not the new one, says the new results bolster the case for including red giants in searches for habitable planets.

Though close-in planets would be sterilised by the red giant, "maybe there's a new burst of life around a super-Earth farther away", he says.

But James Kasting of Pennsylvania State University, who was not involved in either study, questions the assumptions underlying the new calculations, including setting the optimal temperature for photosynthesis-based life at 50° C, halfway between boiling and freezing.

"50° C would be almost uninhabitable for anything that lives on Earth except for some kinds of bacteria," he says, pointing out that Earth's average surface temperature is around 15° C.

Journal reference: *Astrobiology* (forthcoming)

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