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Full text

Outback Search for Life on Mars

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Abstract (summary)

The ocean may have covered most of the Earth and there was probably no polar ice - the water temperature could have been as high as 800C due to planetary heat rather than from the Sun, which was 20% less luminous than it is today. [...] the technique used which measures a planet's gravitational pull on a star - can only detect massive planets like Jupiter and Saturn.

Full Text

Headnote

What can we learn about life on Mars from ancient rocks in Western Australia and recent discoveries made by a string of Mars obiter spacecraft, a polar lander and two rovers?

In a remote corner of Australia you will find the world's earliest convincing evidence of life on Earth. The evidence, in the Pilbara area of Western Australia, tells us that life got going on Earth early in its history, before 3.5 biilion years ago - and on a planet that would look like an alien world to us compared with Earth today. It is a link to our place in the cosmos, and may provide clues to the possibility of past or present life on Mars. It is an important key in recognising ancient life forms on Mars, and to determine - even without the presence of organic material - that the evidence is as convincing on the red planet as it is on Earth.

The squiggles, lumps and mounds left 3.42 billion years ago in the Pilbara by microbial mats - known as stromatolites - have been hotly debated as to whether or not they are evidence of early life on Earth. But the work of one of our former students at the Australian Centre for Astrobiology, Abigail Allwood, and others has largely changed that view.

Abby's paper in Nature (June 2006) demonstrated that a collection of some of the shapes in the ancient rocks of the Pilbara have the form of a microbial reef extending tens of kilometres and across at least seven separate forms of stromatolites. It would be extraordinary if geological processes had expertly copied the biology of such a reef - the only other explanation and the basis for the debate on whether the shapes in the rock were made by geological processes or life.

There are also somewhat less wellpreserved stromatolites 3.5 billion years old in the same region that have been studied in detail by Martin Van Kranendonk of the Geological Survey of WA.

It is difficult to imagine the great age of these fossils - or even grasp that the only inhabitants on Earth were microbes for most of its 4.6 billion year history, with animal life not rising until around 600 million years ago and terrestrial plants even more recently.

But within die ancient remnants of die microbial mats, and among the related cyanobacteria of today, lies a biological story of die cosmos. We fit into the bigger picture - and perhaps one where there might be examples of other multicellular organisms and even intelligence on worlds beyond the solar system.

We do not know how life got started on early Earth. We do know that once the right conditions were there - even though those conditions were quite hostile - life began to thrive. There was no oxygen to speak of; no grass to clothe the plains; no lichen to cling to the rocks. The ocean may have covered most of the Earth and there was probably no polar ice - the water temperature could have been as high as 800C due to planetary heat rather than from the Sun, which was 20% less luminous than it is today.

The details are debatable, but what is probable is that there was no ozone layer. Earth was being flooded by UV solar radiation that is now largely absorbed by the ozone layer.

Nevertheless, the microbial mats that formed the stromatolites were flourishing in a shallow sea or lagoon in the ancient past of the Pilbara area. They formed in relatively quiet periods between very active volcanic episodes. There was enough of a respite for life to have gained a toehold in the shallow waters where fine sediment accumulated .

The first microbes were extremophiles - single-celled forms that enjoy life at the extreme. Extremophiles are still evident on Earth today, and in many types of extreme environments. Examples include extreme heat and cold, high salt concentration and high pressure. Some microbes live kilometres below the surface of the crust where it is hot, the pressure is high and there is no sunlight. Others make a living in cold, high deserts where rain comes rarely.

The extremes of life were first recognised in the 1970s, ri-0.4 (y) 3 (r) 0.4 (r) 0.4 (o) 0.4 (u) 0.4 (n) 0.2 (d) 0.4 (th) 0.2 (e) 0.3 ( ) 0.p3 (d) 0.45.4 (r) 0.2 (s our view of the potential for life on Mars and beyond: that life can survive and thrive in extreme environments outside of the bounds we once imagined.

Another piece of evidence that allows us ro go back even further is the ratio between the different forms of an element such as carbon. For every carbon- 1 3 atom there are on average 89 carbon- 12 atoms. In living things that ratio changes because of biology's preference for carbon- 1 2. That carbon isotopie signal can be traced back 3.5 billion years, and some contend 3.8 billion years.

Zircons found in the Jack Hills of Western Australia show that liquid water was present 4.2 billion years ago, and that the building blocks for life were possibly there too. It suggests that if life got going so early on Earth it is possible that Mars and several moons of both Jupiter and Saturn also played - or still play - host to at least microbial life.

In spite of all of this, not a single extraterrestrial microbe has been found beyond the Earth's biosphere. The exception was Earth bacteria surviving for a number of years on a camera retrieved from an unmanned lunar lander (Surveyor) by Apollo astronauts. The bacteria "woke up" when offered ambient temperatures and growth medium back on Earth.

Nevertheless, the appropriate cliché is that the absence of evidence is not evidence of absence. So we press on with questions that pose more questions leading to the biggest questions of all. Where did we come from? Are we alone in the universe? What is our future in the cosmos? These are the big questions of astrobiology.

We are now confident that Mars had a wet and warmer past. Whether this period lasted long enough for life to have emerged is still unknown, but the clues have been mounting for not only that possibility but the chance that life still exists on Mars today.

All life as we know it needs the presence of liquid water to some extent. It seems that pure liquid water cannot exist on the surface of Mars because of the very low pressure there. When the temperature rises (up to 20°C at the equator) any ice "sublimes" to vapour; there is apparently no temperature at which the ice becomes liquid.

Finding intelligence elsewhere in the universe would change our way of thinking. Very quickly it would be understood that the vast distances in space make a trip there or by them to us very unlikely. But we would know that we are not alone in the unimaginable vastness of the cosmos. We would also know that at least on one other world intelligence has survived its childhood, not by a few thousand years but perhaps millions or billions ofyears.

The Australian Centre for Astrobiology spans geology, paleobiology, microbiology and astrophysics. In the latter area we have an active program in the search for extrasolar planets, of which more than 350 are now known. However, the technique used which measures a planet's gravitational pull on a star - can only detect massive planets like Jupiter and Saturn.

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