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Microbes and Mud: Give Scientist Clues About Life on Mars...and Earth

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In this issue....

Microbes and Mud Give Scientist Clues about Life on Mars... and Earth

The Strange Stromatolite

Peg Van Patten

Rapid Evolution Rampant at Sea

Hans G. Dam

Marine Protected Areas: an Ecosystem-Based Fisheries Management Tool

Bob Pomeroy

Lobster Resource Showing No Signs of Recovery as Research Progresses

Nancy C. Balcom

Gifted and Talented Youth Join Marine Scientists for a Day of Fun and Science

Nancy C. Balcom
NASA’s Mars Rover is expected to provide geologic samples from the surface of the Red Planet in 2004. Meanwhile scientists are already studying rocks and sediment from Space for microfossils and other clues that may tell us whether life is, or was, present.

Astrobiologists hope to determine whether other planets in the universe have supported life or may be evolving the precursors to life as we know it.

Photo: National Aeronautics and Space Administration (NASA)
Pieter Visscher’s work is out of this world—sometimes literally, as he works with the NASA Astrobiology Institute as part of the Pale Blue Dot project team. Astrobiologists study the origin, evolution, distribution, and future of life on Earth and in the Universe, so part of their mission is to seek life beyond Earth. Extraterrestrial life is a very real possibility from Visscher’s perspective (which due to the nature of his research, is a bit broader than most).

Besides seeking the true answer to the old question, “Are we alone?”, astrobiologists want to identify planets that may have the potential to support life, should humanity ever feel the need to migrate on a grand scale.

The “Pale Blue Dot” is how author Carl Sagan described Earth as viewed in a photo taken by U.S. astronauts from deep space, and the name underscores the importance of scale and perspective in scientific pursuits. Ironically, this planet that defines our very existence is barely visible in the grand scheme of things. Visscher, both a biogeochemist and an astrobiologist, looks at life from our biggest lenses—information provided by instruments aboard NASA spacecraft, such as the Hubble telescope, to our tiniest—the specialized electron microscopes in the university laboratory, and tries to put the observations together.

“I truly believe that there is life on Mars,” Visscher says, “and that, when we find it, it will be aquatic and subterranean.” No, he doesn’t wear a tin foil hat or talk to tiny green men. What he does do, as an Associate Professor of Marine Sciences at the University of Connecticut, is use high-tech tools such as a scanning laser confocal microscope and microauto radiography to examine the activities of tiny green-blue cyanobacteria and other primitive life forms that were present during our planet’s early days, as well as organic cycles that determine how sediments form and persist.

It’s not as strange as it sounds. Recent photos of Mars taken during the NASA Odyssey mission show channels thought to be the remains of early rivers that once cut patterns through the surface of the Red Planet, and dirty ice was found below the Martian surface in 2002.

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A debate still rages on as to whether crystals found in a meteorite that broke off of Mars are fossilized remains of life or not. And clouds have been observed in the atmosphere of some distant planets. “The problem is, we don’t yet know what’s under the clouds—could there be a Sea Grant office on the surface obscured by the clouds?”

Joking aside, Visscher explains that before we can identify, confirm, or understand emerging or evolving life in space, we need to understand what early life and the environment of Earth was like long before humans came into the scene. In other words, we need to know where we’re coming from before we can predict where we’re headed.

“Biogeochemistry combines three disciplines—biology, geology, and chemistry,” Visscher explains. “That’s important because it’s the combination of processes in nature, rather than the individual ones, that allow us to better understand our environment and predict what may happen when it is perturbed.” His pursuits focus on what happens to simple organic compounds—the stuff of which life is made—in the coastal sea.

To find out about early life on Earth, Visscher works with a team on a project fondly called RIBS (Research Initiative on Bahamian Stromatolites). It has nothing to do with Baby Backs or barbecue sauce—rather, it has to do with the study of stromatolites, a type of microbial reef found in shallow seas. Stromatolites consist of layered rock composed of tiny crystals produced by microbial organisms. Some say they cannot correctly be called either living or nonliving, since it is an interactive combination of both. These strange mounds found in coastal waters represent the intertwining of simple life forms such as blue-green bacteria with layers of sediment formed from their secretions, to form large multi-layered structures. Stromatolites were quite common in the Precambrian period of Earth’s history, but are rare now. Until 35 years ago, existing examples were unknown, then stromatolites were discovered at Shark Bay, off Australia. Seventeen years ago, more formations were found off the Bahamas, and these are now considered to be the only known living examples. The earliest fossilized stromatolites are more than three and a half billion years old, and thus are evidence of the very earliest life on our planet. Some grew to the size of today’s typical house. If life is emerging on other worlds with similar conditions, Visscher thinks it will likely be similar.

The RIBS team includes experts in many fields, in order to get the big picture of how life forms, geological sediments, and chemical cycles are interacting. Visscher’s primary role is to examine geochemical processes such as the sulfur cycle. Why sulfur? Most of us who poke around wrack lines, if we think of sulfur at all, connect it with the pungent odor of low tides or the stink of rotten eggs (hydrogen sulfide). Others recall that highly flammable yellow stuff in chemistry class—those of a certain age might come up with the term “brimstone”. Sulfur originates in the Earth’s crust and enters the atmosphere and oceans as a gas, then, once oxidized, may fall back to earth as weak sulfuric acid, better known as “acid rain”. When taken up by plant roots, sulfates, the soluble forms of sulfur, are incorporated into some amino acids and become, as it travels through the food web as part of animal proteins. As organisms decompose, the sulfur is released again as gas.

In the case of stromatolites, those strange “living rocks”, layers of green or purple bacteria colonies called “microbial mats” cycle sulfur, and as a product secrete calcium carbonate (limestone to us—the same stuff that forms the shells of clams, crabs,
and the like). Some of the reactions that occur in nature involving sulfur are those that either make life possible in new environments or, conversely, make the environment uninhabitable to some organisms. It is bacteria using sulfur for energy that facilitate life in the fiery hydrothermal vents at the sea bottom, for example. Sulfur reactions in the atmosphere are very important in the context of climate change, and indeed in determining which organisms can survive on a planet. In the sediments it is found mostly as gypsum (calcium sulfate) and iron pyrite; in the ocean it is found in many forms.

Peering at mud and microbes in the laboratory, Visscher can see a world in miniature— evidence of the complex layering involved in stromatolite formation.

First, a “pioneer” colony of blue-green microbes moves in, forming the first layer by clustering together and secreting a gooey substance which traps falling grains of sand. As they become buried in sand and goo, the bacteria then migrate upward. Next, another species of sulfate-cycling bacteria group above the first layer. These tiny but very active organisms produce a different goo, containing calcium carbonate. This forms a new, thin layer of hard white crust.

Peering at mud and microbes in the laboratory, Visscher can see a world in miniature— evidence of the complex layering involved in stromatolite formation.

Finally, a third type of cyanobacteria colonize the surface of the crust. They bore through the sand grains by dissolving them, then calcium carbonate “glue” fills the holes, cementing the whole tiered structure together into a whole. Thus the primitive structures are formed by the complex interaction of three distinct communities with sand.

Using microelectrodes, Visscher measures sediment characteristics, such as oxygen and sulfide levels, pH, redox potential, and temperature, to find out and compare what conditions were conducive to early life and what makes a good “home” today. He also determines which tiny organisms are present, and finally assembles the information into “profiles” used to devise laboratory experiments with sediments and cultured microbes.

Visscher uses the same techniques to study other critical habitats, such as seagrass beds in Long Island Sound and the functioning of marine ecosystems.

These investigations will gain momentum as the NASA Mars mission progresses rapidly, with two unmanned missions underway, and a Martian Rover surface sampling mission planned by 2004. In the meantime, the interactions of microbes and minerals may have a more immediately practical application for Earthlings, if new ways to produce energy can be found.

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