Life in Hostile Places

by Tom Mason, Director

When I was still working as a Geology professor in Africa, I spent a lot of time in Namibia researching ancient river and lake deposits, and finding fossil evidence of life in the Namib Desert when it was a more pleasant place to live, being much wetter than today. The Namibian rocks contain some dramatic evidence of the sudden climatic shifts that humankind may be about to face now, as the Earth's overall temperature rises. The ancient Namibian lake beds had fossil plants and animals around their margins that would not survive there today as, apart from sporadic showers every seven years or so, the only moisture to be had is from the dense sea fogs that roll inland from the South Atlantic. The fogs are created by the cold water of the Benguela Current meeting very much warmer air from the African continent. This means that the air over the Namib is unusually humid and fogs are extremely common. The desert outcrops show that there were a number of wetter climatic cycles at various times during the past 65 million years. The evidence is found in Etosha Pan near the Angolan border, and at various sites in the Namib ranging in age from mid-Tertiary to Pleistocene. There is evidence that during wet seasons the rivers periodically flooded, and there is ample evidence that large animals that must drink daily to survive once lived there, as well as hosts of smaller creatures that have rather more specialist life-styles.

What strikes people most forcefully when they enter the Namib Desert for the first time is that while it is very hot and dry, there is often quite a lot of life, clinging on to existence in odd places. In almost all cases this means that there is a water source somewhere nearby, either metres deep underfoot or close by as a seep or spring from the rock strata. The water is often very brackish and foul tasting, but plants do not seem to mind. As a rule of thumb, if you can irrigate, then things will grow. For some dramatic examples, see the Libyan Desert on satellite images showing irrigation circles at http://earthobservatory.nasa.gov/Newsroom/NewImages/Images/ISS010-E-5266_lrg.jpg

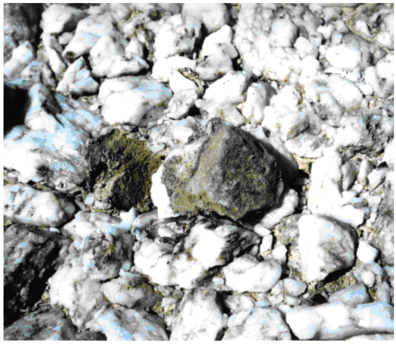

Image Credit: Ute Schmiedel University of Hamburg, Botany Department

Window algae This shows the under surface of a white quartz pebble, normally protected by the pebble and in the desert soil. The greenish coating is made by algae living under the quartz. Conditions of light penetration through the pebble, temperature and a supply of condensed moisture from fog are sufficient for the algae to thrive. Such microhabitats in the extreme climate of Earth's deserts provide clues as to where we should look for signs of life on Mars.

Southern hemisphere night skies are spectacularly bright and full of interesting sights. But you will discover for yourself the richness of night time desert life as you must be careful not to find a sand dune and lie down without looking as small poisonous snakes and scorpions are active at night. During the day they lie low, many of them underground. And if you excavate a tunnel in the sand sea during the day, digging deeper into the sandy soil, you will detect coolness and even a hint of dampness. Zebra and elephant often dig down to the water table in the dry river beds, for even though there is no water flowing in the river, there is a constant underground flow. This shows up as green lines of deep rooted vegetation that can exploit this hidden supply. Namib plants are adapted to minimise moisture loss by transpiration, and in some extreme cases, like the Nara melon, a sort of squash, the plant has no leaves at all, but photosynthesises using its stems and the long thorns that festoon them.

The desert surface can be gravelly, sandy or rocky: the gravelly desert surfaces often include translucent quartz pebbles, sculpted into weird shapes by the sand blasting effect of the wind. As the fogs roll inland and condense on the pebbles, liquid water runs down the side of the pebble and into the soil beneath. The critical combination of soil, water and sunlight allows lichens and algae to grow. Lichens are a symbiotic collaboration between an alga and a fungus. The two can survive together where they would perish on their own. Lichens can take many forms, but the most beautiful are those that are brightly coloured: vivid scarlets, sulphur yellows and various hues of green. The contrast with the crustose lichens could not be more striking, as these tend to be rather dull dark browns and blacks. The lichens' main ability is to survive where all else dies. It is long-lived and slow-growing, and the comparison with Mars is worth making.

> "There is water in abundance under the surface of Mars"

From what we know of Martian surface conditions there is water in abundance under the surface. The Viking spacecraft of the 1970s scraped the surface to look for evidence of biological activity. With the benefit of hindsight this was a mistake, as the surface is likely to be sterilised by the fierce solar radiation, even at the distance Mars is from the Sun, its thin atmosphere provides no shield against the radiation that we are spared on Earth because of the absorption in our thick atmosphere. But if there is water, there may be life. It is true that on Earth we are now discovering life in places where we would not have looked in the past because conditions were so extreme. But the extremophiles, as they are now known, can be found in places that we would find uncomfortable at best, and at worst fatal. ESA's Mars Express spacecraft has used its MARSIS radar probes to penetrate up to 5 km under Mars' surface , and to demonstrate major deposits of frozen underground water. Another recent discovery (released December 2006)

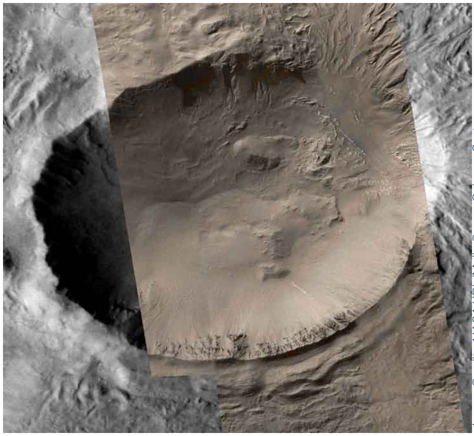
Image Credit: NASA/JPL/Malin Space Science Systems

Unnamed crater in the Centauri Montes Region This is a mosaic of several Mars Global Surveyor images, colourised using Mars Reconnaissance Orbiter camera colour data and overlaid on part of a Mars Odyssey Thermal Emission Imaging System image

showed that liquid water may have flowed on Mars during the past seven years. Two images of the same part of a crater margin in the Centauri Montes region, taken by one of NASA's Mars Global Surveyor cameras, shows that liquid water has formed a brighter gully deposit, similar to those that occur in arid regions on Earth. While this work is tantalising, it is still inconclusive, as we do not know what mobilised/thawed the frozen water. It shows that we need to carefully examine old and new images to seek changes that have occurred over a short time span. This would be akin to astronomers using photographic plates in blink comparators to seek out asteroids and other phenomena moving in star fields.

Viking's experiments looking for signs of biological activity in the Martian soils were equivocal and they raised more questions than they answered. If we could safely transport humans to Mars with a mission of sufficient length that they could explore a large area, we will find out much more than by using robots. The physical dangers to the astronauts may be reduced by new ideas involving magnetic field generators which could be used to make strong magnetic fields that could shield astronauts in their relatively flimsy craft from damaging radiation during their three

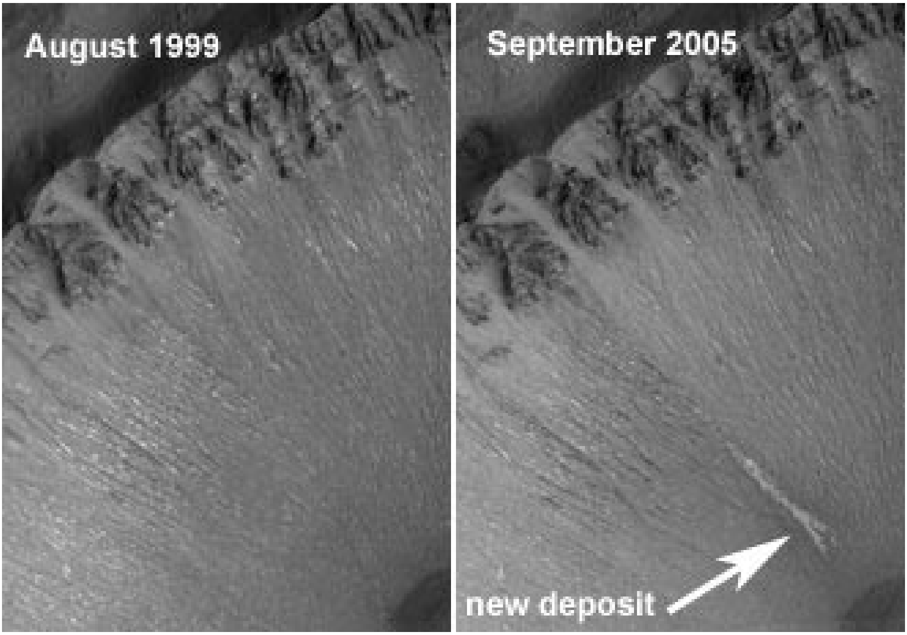

Image Credit: NASA/JPL/Malin Space Science Systems

Crater wall in close-up, as it appeared in August 1999, and later in September 2005. No light-toned-deposit was present in August 1999, but it had appeared by February 2004.

year round trip. This may go some way towards solving what is a huge risk, which is the danger of excessive radiation exposure on such a long trip to Mars and back. The Earth's magnetic field protects us, so maybe an artificially generated field within the space craft could do the same for Martian explorers. Of course the Martian water, liquid or frozen, is a raw material that will allow exploitation of the hydrogen for fuel and the oxygen for life support, using simple electrochemical separation.

For now, the research that is being carried out on the desert environments on Earth may hold the keys to unlocking the secrets of Mars.