

# nano

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## UNDER THE MICROSCOPE

Nanotech on another planet

Micro Nano Pico

First pico-scale images revealed

The Nose Knows

An electronic nose for explosive detection

Fingerprints

Just got smarter

France

Driving force for future techs

What's New in Nano

Keep up with the latest news

X-ray holograms

Brighter, Faster, Sharper

Laurent Malier

CEA-Leti Director speaks his mind

March of the Nanorians

Fun-sized view of nanotechnology

PLUS: SMALLER SMARTER BETTER LEGAL IMPLICATIONS OF SMART SURVEILLANCE



# nano

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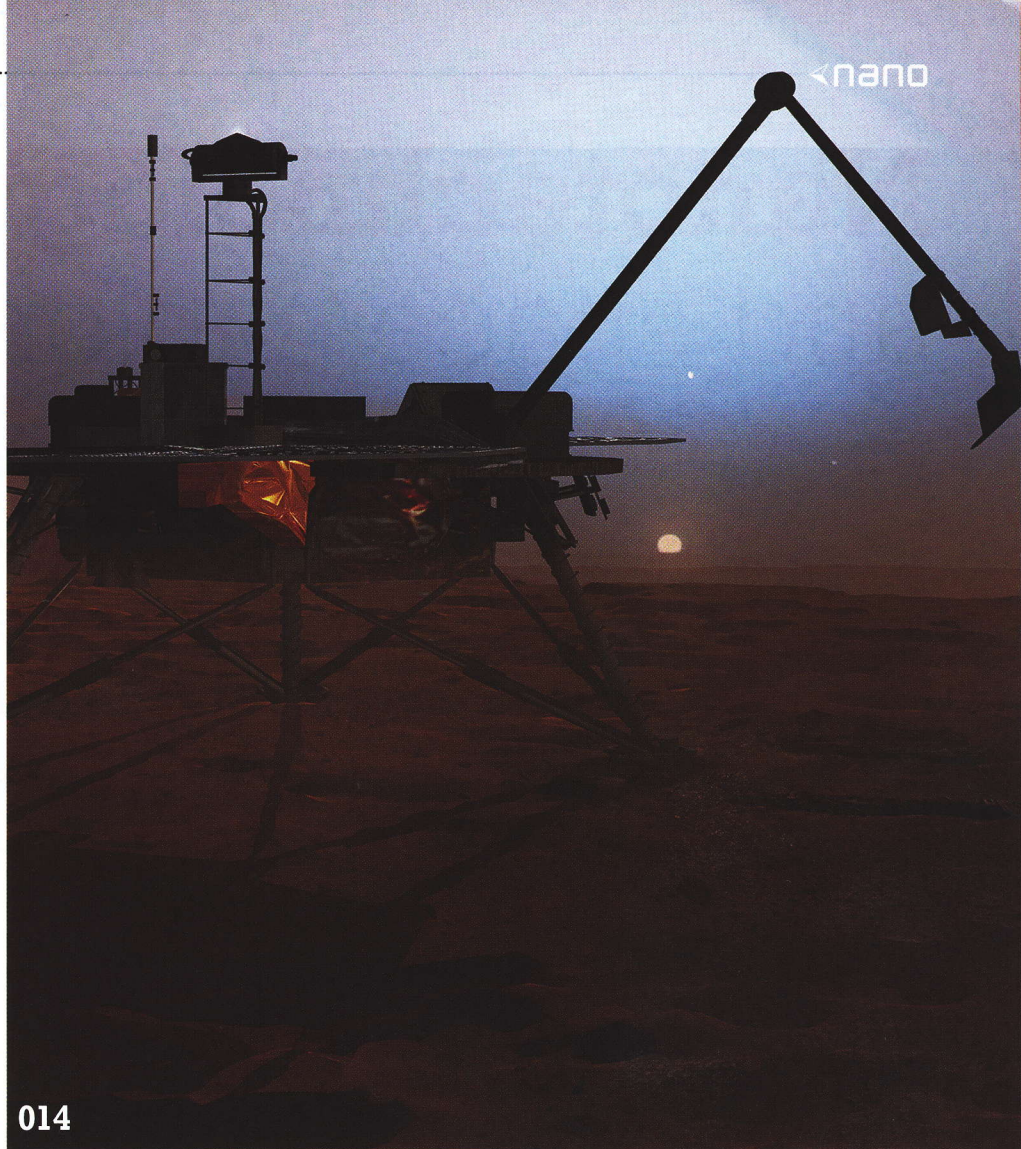
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014

## FEATURES

### Microscopes on Mars .....014

Fine images of red dust

### Micro Nano Pico .....018

The evolution of microscopy

### The Nose Knows .....020

An electronic nose for explosive detection

### Smart prints .....032

Fingerprints working underwater

### March of the Nanorians .....035

Potentials and applications of nanoparticles

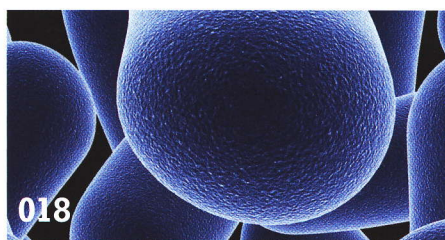
### X-ray holograms .....036

Brighter, faster, sharper

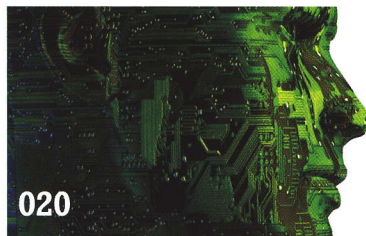
## COUNTRY PROFILE

### France .....024

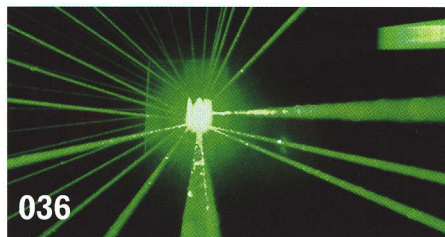
A driving force for future techs



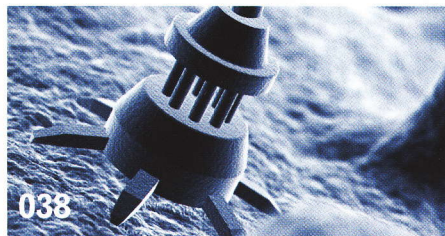
018



020



036



038



040

## ESSAY

### Nano2Life winning essay .....035

## COMMENT

### Smaller Smarter Better? .....040

Legal implications of smart surveillance

## INTERVIEW

### Laurent Malier .....027

CEA-Leti director speaks his mind

## REGULARS

### Editorial .....004

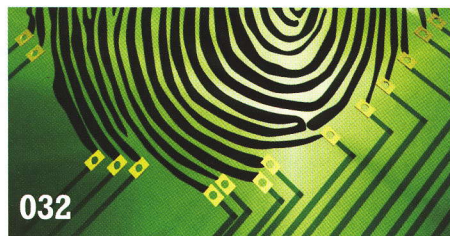
### Events .....006

### What's new in nano .....008

### Books .....013

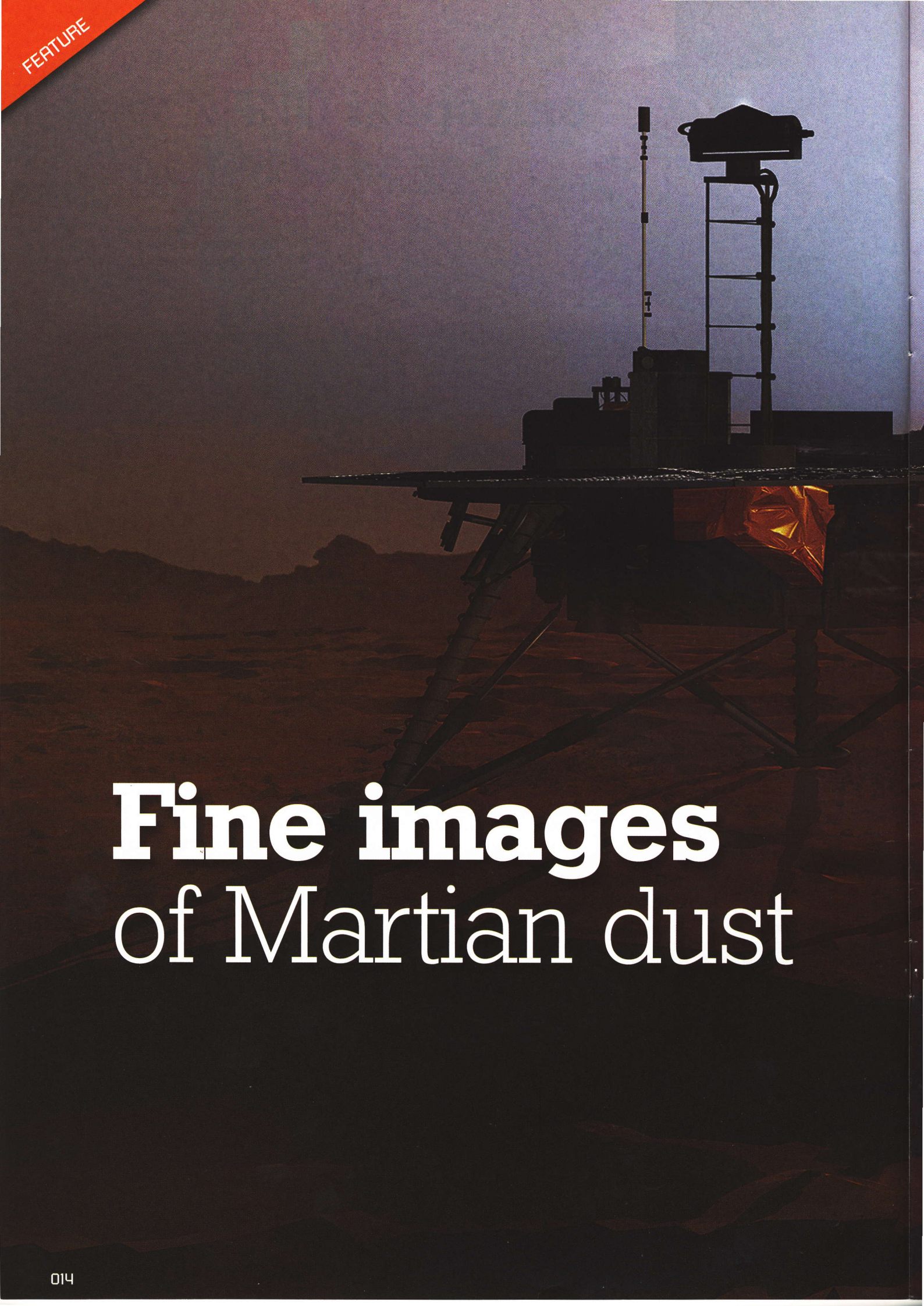
### Nanomedicine .....038

### Nanoart .....042



032





# Fine images of Martian dust



**AN ATOMIC FORCE MICROSCOPE ON BOARD NASA'S PHOENIX LANDER, CURRENTLY SITTING ON THE ARCTIC POLE OF MARS, HAS RETURNED THE VERY FIRST IMAGE OF A SINGLE PARTICLE OF DUST FROM THE RED PLANET, PROVIDING NEW CLUES ABOUT THE HISTORY OF WATER ON MARS AND TAKING ANOTHER STEP TOWARDS THE POSSIBILITY OF A MANNED MISSION.**

The image is about 20 times smaller than what can be resolved with the optical microscope on board the spacecraft, and a much higher resolution than anything seen on the Martian surface to date.

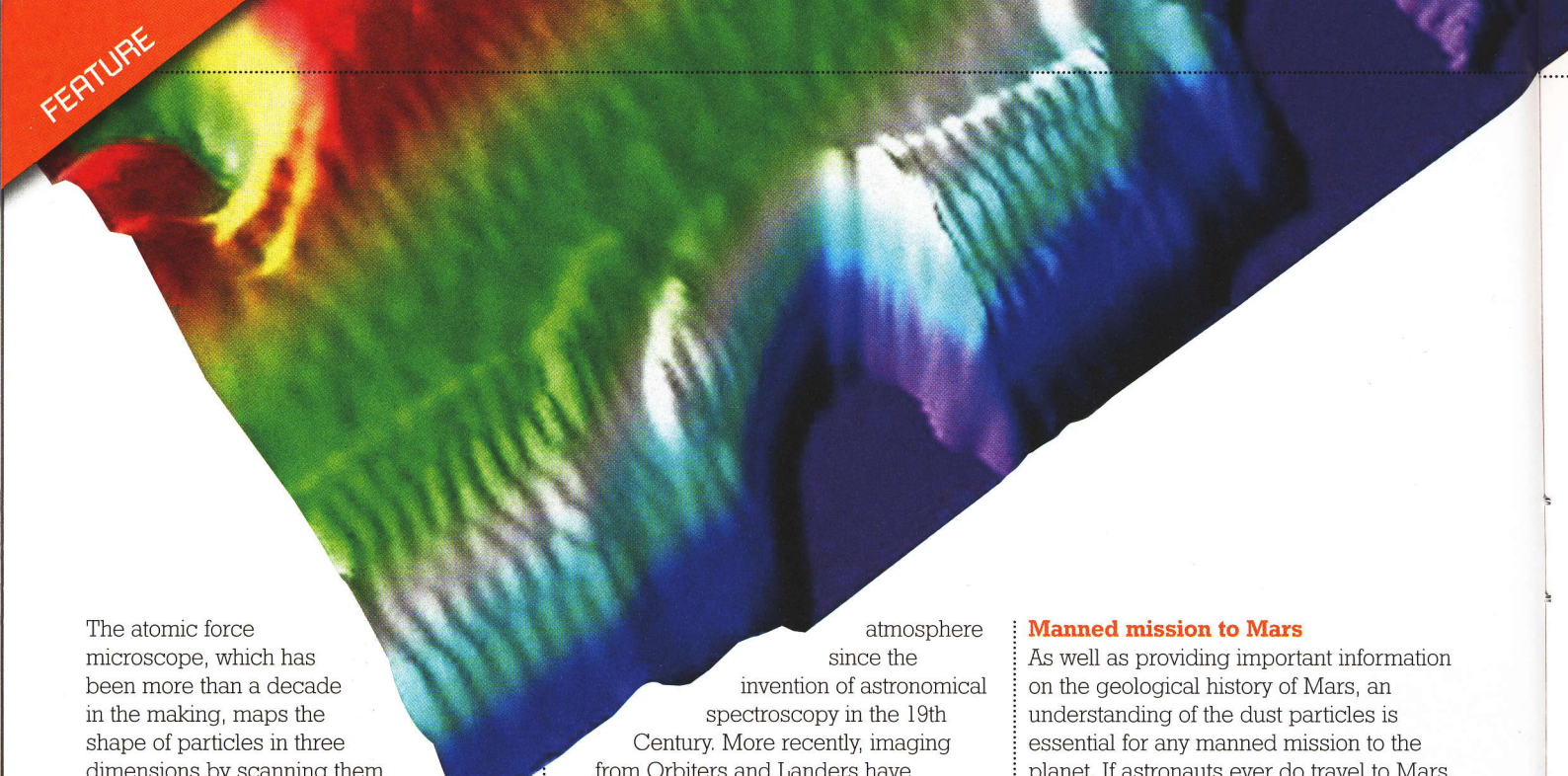
The speck of dust imaged is one of billions of particles that cloak Mars. Such dust particles colour the Martian sky pink, feed storms that regularly envelop the planet and produce Mars' distinctive red soil.

"This is the first picture of a clay-sized particle on Mars, and the size agrees with predictions from the colours seen in sunsets on the Red Planet," said Phoenix co-investigator Urs Staufer of the University of Neuchatel, Switzerland, who leads the Swiss consortium that made the microscope.

"Taking this image required the highest resolution microscope operated off Earth and a specially designed substrate to hold the Martian dust," said Tom Pike, Phoenix science team member from Imperial College London. "We always knew it was going to be technically very challenging to image particles this small." →

Image: NASA/JPL





The atomic force microscope, which has been more than a decade in the making, maps the shape of particles in three dimensions by scanning them with a sharp tip at the end of a spring. During the scan, invisibly fine particles are held by a series of pits etched into a substrate micro-fabricated from a silicon wafer. Pike's group at Imperial College produced these silicon microdiscs.

The atomic force microscope can detail the shapes of particles as small as about 100 nanometers, about one one-thousandth the width of a human hair. That is about 100 times greater magnification than seen with Phoenix's optical microscope, which made its first images of Martian soil about two months ago.

"I'm delighted that this microscope is producing images that will help us understand Mars at the highest detail ever," Stauffer said. "This is proof of the microscope's potential. We are now ready to start doing scientific experiments that will add a new dimension to measurements being made by other Phoenix Lander instruments."

"After this first success, we're now working on building up a portrait gallery of the dust on Mars," Pike added.

### Red dust

Fine red dust covers the landscape of Mars and fills the atmosphere. If you stood on the surface of the planet and looked up, the sky would be red. Astronomers looking from afar have dubbed Mars the Red Planet due to the reflected red glow from the particles that hang in the Martian air. Aside from painting a pretty picture of Mars, scientists believe the fine red dust particles hold a wealth of information about the history of the planet and a major component of the current Mars mission is to learn more about their structure and composition.

Scientists have attempted to analyse the chemical composition of the Martian

atmosphere since the invention of astronomical spectroscopy in the 19th Century. More recently, imaging from Orbiters and Landers have provided information on the composition of the dust particles that surround the planet. The Phoenix mission takes this a step further providing detailed analysis and imagery of fine grains recovered from the surface of the planet.

"By understanding the mineralogy of the surface materials on Mars, we can gain insight into the availability of liquid water and the duration, mode and extent of weathering occurring throughout Martian history. For example, we know that silicon and iron are the two most abundant elements on Mars, but don't know how they are combined into surface minerals," says Sebastian Gautsch from the University of Neuchatel, one of the lead researchers on the AFM development for Phoenix.

Analysis of the airborne particles present in the atmosphere has been a focus of research for many decades. However, until now, it has been impossible to accurately measure the size and shape of individual particles. The new AFM images will also provide information on other factors such as the hardness and mass of the dust particles.

"Although properties of the dust have been inferred from remote sensing and evaluated by surface experiments, there has been no imaging of individual dust and soil particles to determine their size distribution and shape. Such information is essential in understanding the contribution of the particles to the Martian climate and its geological past," Gautsch says.

"Until now, understanding of the mineralogical composition of the dust particles was dependent on theoretical interpretation of diffraction models. The AFM measurements will provide much more accurate, less speculative information about the mineralogical history of the particles."

### Manned mission to Mars

As well as providing important information on the geological history of Mars, an understanding of the dust particles is essential for any manned mission to the planet. If astronauts ever do travel to Mars, it is likely they will stay on the planet for a number of days or weeks, much longer than the few footsteps taken by astronauts on the Moon in 1969.

Safety is therefore of paramount importance and whether or not the dust particles pose a hazard to humans or their electronic equipment or even the spacecraft, must be determined before any mission takes off.

Particles can stick to an astronaut's spacesuit, for example, and enter the spacecraft where it could potentially be inhaled or ingested or cause corrosion to the internal workings of the craft.

Examples of potential hazards that may face astronauts or craft include abrasion, where hard particles, such as quartz, could scratch surfaces, and corrosion, whereby dust particles react when they come into contact with other materials. Specific corrosion hazards for Mars explorers include corrosion of space suit materials and airlock seals.

One of the most important risk factors that scientists need to consider is the potential for unfamiliar toxic particles to make an astronaut ill. Breathable quartz particles, for example, are known to be among the most dangerous particles on Earth, responsible for many deaths from silicosis among mining and construction workers over many years. Quartz is believed to exist on Mars and could potentially be the most hazardous substance for both man and machinery on the planet. The abundant presence of this mineral on Mars would be a serious threat to a manned mission to Mars for engineering and health issues. The Phoenix team hope their analysis will help shed some light on these and other particles present on the surface of the planet.



## MECA

The atomic force microscope is one component of an extremely sophisticated Microscopy, Electrochemistry and Conductivity Analysis (MECA) unit on the Phoenix Lander, which touched down in Mars earlier this year. MECA is just one of seven laboratories on board the Lander, which are all feeding back information about the planet in one of the most successful space missions in recent years.

MECA was built by a team led by Dr Michael Hecht at NASA's Jet Propulsion Laboratory.

MECA characterises the soil and dust of Mars much like a gardener would test the soil in his or her garden. It contains four wet chemistry labs, each with beakers that can accept samples of Martian soil. A robotic arm attached to the Lander scoops soil from the ground and loads it into the beakers for analysis. Various pieces of equipment stir, mix and prepare the samples for analysis before more information about their acidity and structure can be uncovered.

Also onboard MECA is a thermal and electrical conductivity probe for measuring the thermal and electrical properties of the soil, which will provide an indication of the ice and water content in the soil.

Optical and atomic force microscopes complement the wet chemistry experiments. With images from these microscopes, scientists can examine the fine detail structure of soil and water ice samples that may indicate a history of water on the planet. The optical microscope has a resolution enabling the detection of particles down to ten micrometres. The atomic force microscope in contrast, will enable imaging down to a resolution of just 10 nanometres – the smallest scale ever examined on Mars. Using its sensors, the AFM creates a very small-scale topographic map illustrating the detailed structure of soil and ice grains.

The microscopy station includes a tool for performing simple mineralogical scratch and streak tests on the particles from the Martian soil. Different pressures will be applied to individual particles to create tiny scratches on the surface, which can give an indication of the hardness of a particle, and thereby help to identify it. Quartz for example, is a very hard particle. The atomic force microscope will enable the scientists to look at the profile of these tiny scratches in detail to help identify the various minerals present in the soil.

## Looking for life

Laboratory tests from Phoenix have already identified water in a soil sample uncovered by the robotic arm from about five centimetres below the surface. The finding was announced in July this year by William Boynton of the University of Arizona, the lead scientist on the thermal and evolved gas analyser (TEGA) on board Phoenix.

"We have water," Boynton announced. "We've seen evidence for this water ice before in observations by the Mars Odyssey orbiter and in disappearing chunks observed by Phoenix, but this is the first time Martian water has been touched and tasted."

Besides confirming the 2002 finding from orbit of water ice near the surface and deciphering newly observed stickiness of the samples, the team is trying to determine whether the water ice ever thaws enough to be available for biology and if carbon-containing chemicals and other raw materials for life are present.

The mission is also throwing some surprises. The unexpected discovery of perchlorate salts has changed how some scientists view Mars. Perchlorate is a known oxidant – meaning it can release oxygen. Some microorganisms on Earth are fuelled by processes that involve perchlorates so the finding is generating some cautious excitement.

Hecht explains, "Finding perchlorates is neither good or bad for life, but it does make us reassess how we think about life on Mars. Different types of perchlorate salts have interesting properties that may bear on the way things work on Mars if – and that's a big 'if' – the results from our two teaspoons of soil are representative of all of Mars, or at least a significant portion of the planet."

Phoenix will continue to relay new data and discoveries about the Martian soil back to Earth for another month yet, outliving its original intended mission duration by a number of weeks. ✨

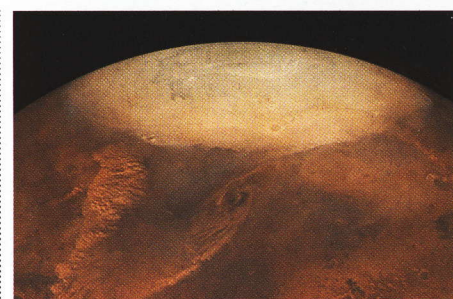
## Further reading:

Sebastian Gautsch (2002) Development of an atomic force microscope and measurement concepts for characterising Martian dust and soil particles. ISBN 3-935511-24-8

More information: [www.nanosurf.com](http://www.nanosurf.com) and [www.nasa.gov/phoenix](http://www.nasa.gov/phoenix)

*The Phoenix mission is led by Peter Smith from the University of Arizona with project management at NASA's Jet Propulsion Laboratory, Pasadena, California, and development partnership at Lockheed Martin, Denver. International contributions come from the Canadian Space Agency; the University of Neuchatel; the universities of Copenhagen and Aarhus in Denmark; the Max Planck Institute in Germany; and the Finnish Meteorological Institute. The California Institute of Technology in Pasadena manages JPL for NASA.*

*The Phoenix AFM was developed by a team including the Institute of Micro-technology of the University of Neuchatel, the Institute of Physics at the University of Basel and the Swiss company Nanosurf.*



## Missions to Mars

- 1965** NASA's Mariner 4 completes first flyby of Mars collecting the first close up images of another planet
- 1971** Russia's Mars 2 and Mars 3 probes land on the red planet but lose contact within seconds
- 1971** NASA's Mariner 9 IRIS experiment returns infrared images of the planet
- 1976** NASA's Viking mission, consisting of two orbiters, successfully touch down. Viking 1 remained operational for six years, Viking 2 was operational for three years. The Viking landers returned the very first colour pictures of Mars
- 1997** Pathfinder lands on Mars and begins characterising the Martian environment using a robotic exploration vehicle (rover) to take pictures and measure the mineral composition of rocks.
- 2001** Mars Odyssey orbiter launches into orbit – and remains there today
- 2008** NASA's Phoenix Lander reaches Mars

## Interesting facts about Mars

- Mars is about half the size of Earth
- Mars is the fourth planet from the sun in our solar system
- A Martian day lasts about 24 hours and 40 minutes
- A Martian year is almost twice as long as an Earth year (687 days)
- The temperature on Mars ranges from -133°C to +22°C
- The Martian atmosphere is about 100 times less thick than that on Earth
- Martian air is almost entirely made up of carbon dioxide (CO<sub>2</sub>)
- The largest volcano on Mars is about 2.5 times the height of Mount Everest
- The biggest canyon on Mars is about 10 times the size of the Grand Canyon