NESACS Member Interviews

Professor Samuel Kounaves

Professor Samuel Kounaves: on the Phoenix Mission to Mars and beyond

On May 25, 2008, the Phoenix Lander arrived on Mars after a 10-month space flight, carrying on board the first wet chemistry laboratory to perform extra- terrestrial chemical analysis. Tufts University chemistry professor and adjunct geology professor Samuel Kounaves was a co-investigator for the 2007 Phoenix mission to Mars and lead scientist for the wet chemistry lab- oratory. The Nucleus had the chance to interview Professor Kounaves in his laboratory at Tufts University and to learn a little more about his journey as a scientist whose dream, of doing chemistry on another planet to answer fundamental questions about our solar system, had come true.

The concept of sending a wet chemistry laboratory to perform on-site analysis of Martian soil took form back in 1997, when an international group of scientists, including Professor Kounaves, launched a project with NASA for a 2001 mission to Mars. Although the initial mission was canceled unexpectedly by NASA after the loss of the Mars Orbiter in 1999, a new team was put together for a proposal and subsequently funded in 2003 for a 2007 Mars Scout Mission.

When asked about his experience working with NASA and the Phoenix team, Kounaves said he was most impressed to see how NASA managed the project, an assemblage of literally millions of parts from countless sources that ultimately had to survive the rigors of space travel to function properly after arriving on the surface of Mars. The wet chemistry laboratory was part of a larger instrument pack- age, the

Microscopy, Electrochemistry, and Conductivity Analyzer (MECA). MECA also included an optical and atomic force microscope, and a thermal and electrical conductivity probe. The solar-powered robot also carried a meteorological station, a thermal and evolved gas analyzer (basically a scanning calorimeter and mass spec) and, of course, several cameras.

The wet chemistry group at Tufts started work in 2003 under Kounaves' supervision, initially developing several of the sensors and analytical procedures and later characterizing and testing the final sensor assembly. They were also responsible for loading the final reagents into the 5 crucibles for each of the 4 chemistry cells that were sent to Mars, Specially developed Ion Selective Electrodes (ISEs) were used for the detection system, including sensors for sodium, potassium, chloride, magnesium, calcium, sulfate, and perchlorate ions, and for measuring pH. One of the main challenges that the group had to overcome was to design the ISEs to survive and perform under the extreme temperatures and vibrations that they would be subjected to on the way to Mars and during launch and landing, and on the surface during its operation. The device had to survive exposure to temperatures from -80^{o}C to + 60^{o}C for a month prior to analyzing the Martian soil.

When results came back from the mission, the team was very excited to have uncovered how "friendly" Martian soil really is to potentially support life. First, the pH of Martian soil was found to be slightly basic and very well buffered, around pH 8, rather than very acidic, as previously hypothesized. Further soil tests confirmed the presence of sodium, potassium, chloride, magnesium and calcium carbonate in quantities similar to what one finds in Earth's soil. By digging 10 cm underground, the robot further revealed the presence of a solid white material, which the on-board mass spectrometer definitively confirmed to be pure water (ice). Interestingly, unexpectedly high levels of perchlorate, on the order of 1%, were also found in the soil. Although naturally high levels of perchlorates are rare on earth, they are found in arid places such as the Atacama desert in Chile. When asked about the possibility of life on Mars, Kounaves said "We did not find anything that would preclude the soil from being habitable by a variety of organisms, but because of the high levels of UV radiation on the surface, if life as we know it on Earth exists on Mars, it is most likely subterranean."

As a child Kounaves was always curious about science. He was greatly influenced by his father and by science teachers in middle school and high school. "I was born during the days of Sputnik and was brought up with Star Trek," he said, "I always had an interest in science and a curiosity about how the world and the universe work." When talking about his experience working with NASA and being on the Phoenix mission, Kounaves said what he enjoyed the most was working at the cutting edge of science, close to science fiction, to answer fundamental questions about chemistry and life on Mars. "In the lab it is easy to test the pH of solutions, but on another planet it is a real challenge because the environment is so extreme," Kounaves explained. With the success of the Phoenix mission, Kounaves's group has deservedly earned the reputation of being the "extreme analytical chemistry" group. The group is now applying its ability and expertise in developing ISE sensors for extreme terrestrial applications, where "the only way to analyze correctly is to measure in situ," as in deep sea vents or the Antarctic Dry Valleys.

"To understand Earth's climate and be able to produce good models, it is important to understand our two neighboring planets Venus and Mars. Mars is colder than it should be, and Venus is warmer that it should be if you only account for their position in the solar system. So why and how did Mars become so cold? If we build a climate model for Mars that works, we can then apply it to predict climate change on Earth by adding complexity to it. Mars is a simpler system to build a model for because it doesn't have an ocean, for example. There is some evidence that Mars was warmer before, but the planet still holds a lot of mysteries on how the environment changed. The history of a planet is recorded in the chemistry of the soil, so to answer a lot of these questions, we need to taste the chemistry and not just look at it." Kounaves said.

When asked what advice he could give to younger scientists, students, or faculty, who have a dream to participate in complex multi-disciplinary and visionary projects such as in planetary science, Kounaves said that for him the most important thing for success is to first have a solid foundation and expertise in one area of science that can be applied to broader areas such as planetary science, for example. Second, you should chose some area you are passionate about, because "you'll never work a day if you do what you love to do." Finally, you should not have any hesitation about interdisciplinary collaboration, because exploring the unknown in science often requires a wide variety of specializations and expertise.

From an article in the Summer 2009 issue of The Nucleus by Sonia Taktak, Ph.D.