Outer Solar System Chemistry Program

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Understanding the **chemistry** associated with surface composition and processes of outer solar system objects and how the surface interacts with the objects' interior, atmosphere and/or space environment is essential to support major aspects of the NASA *Vision for Space Exploration* (1). Specifically, this is required for the first two goals: "Implement a sustained and affordable human and robotic program to explore the solar system and beyond" and "Extend human presence across the solar system…." It is the surface and its near environs that will be the focus of future robotic and human exploration, as planned by NASA, and it is this interface where the chemical processes can be most active and/or the evidence of major process can be most accessible. Thus, study of these objects and the related processes should emphasize the chemistry and physics of their surfaces and their environment.

These outer planetary bodies exhibit a wide range of temperatures, a substantial water presence, and, frequently, a wide occurrence of carbon and complex organic compounds. In addition, there are a variety of energy sources available, including sunlight, tidal friction, and particle radiation. Thus, outer solar system objects have rich environments for chemical reactions and possibly for supporting life.

NASA has had a major thrust in exploring the outer solar system. Pioneer, Voyager, Galileo and the (current) Cassini missions have provided data on these objects almost continuously since the 1970s. The Pluto mission under development and the JIMO mission, now in the early planning stage, are planning to continue this thrust. The recent very exciting discovery by the Cassini-Huygens of current Titan surface activity demonstrates the continuing potential for discoveries and major surprises.

Along with the need for scientific knowledge of the chemistry and related processes affecting the outer solar system objects is an equal and intimately associated need for a community of scientists to obtain and apply this knowledge. The NASA exploration missions of the past, present and future cannot be successful without hundreds to a thousand or so full-time scientists participating. Since these missions are said to be science-based, there cannot even be a credible justification for them without a strong science community. This community must be composed of a mix of ages and experience as the long time baseline of the missions is similar to or can exceed a scientist's career duration. These scientists are essential at all stages of a mission lifetime, from developing and interpreting the scientific knowledge base to support mission design and development to measurement planning, to data analysis and new knowledge development and eventual communication to taxpayers.

Therefore, we propose a stronger program to support basic research into the chemistry of outer solar system objects. In spite of the justification and need stated above, there is a lack of sufficient and sustained support to develop and apply knowledge in this area and to develop and sustain a science community of sufficient depth and variety. By far the greatest support of the relevant science community at this time is from the flight projects, but this support has been greatly scaled back since Galileo and is mostly directed at highly technical and specific areas of mission support and operations, such as measurement sequence generation and data archiving. Since Galileo, there has been very little NASA funding for mission data analysis and for the basic laboratory and theoretical studies to support data interpretation. The very recent development of the Outer Planets Research Program is a welcome attempt at addressing this deficiency, but it is small and must therefore be focused, and its continuation may be in question. A major concern is that there may well be a gap between the end of the Cassini mission and the beginning of the JIMO mission, during which the outer solar system science community may cease to exist, and when the U.S. may well lose its science capability to fly outer solar science-driven missions.

This broadened outer solar system basic chemistry research program should cover major aspects of the science, including analysis of flight and telescopic data, laboratory studies of candidate materials and processes behavior under OSS environments and theoretical analysis. Study of outer solar system environments is difficult due to the low temperatures and vacuum or reducing environments and the presence of water and organics. Complex and expensive facilities are required, as is a mix of organic and inorganic chemistry expertise that is sometimes beyond that normally available within the planetary science community, indicating the need to team with scientists and facilities from other fields. Of necessity, we need a multi-disciplinary approach to understanding the complex chemistry and physics that occurs on the surface of the outer planet bodies.

Thus, the level of funding per investigation needed might be higher than for less demanding topics. Unless the flight programs return to the Galileo level of funding for investigation scientists, the basic research program will have to carry a significant fraction of the science community needed to justify and support the missions. A WAG of the funding level needed can be obtained by considering a minimum program of 100 science investigations at $200,000 per year, which means $20 million per year.

References:

1) The Vision for Space Exploration, NASA, February 2004.