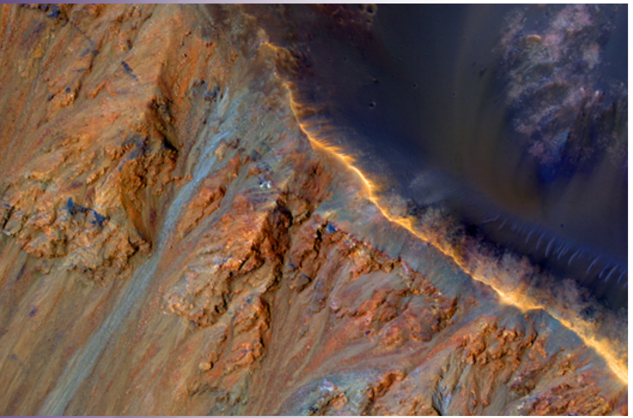
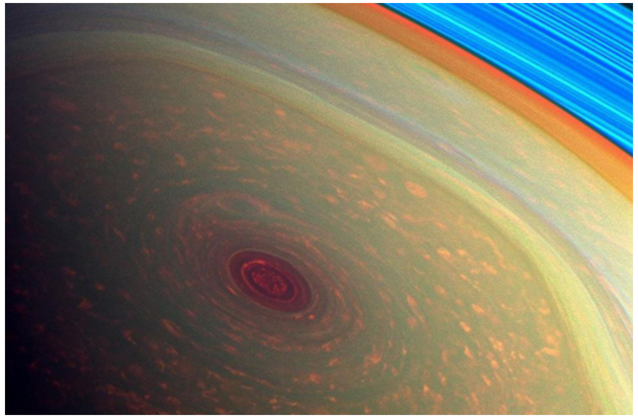
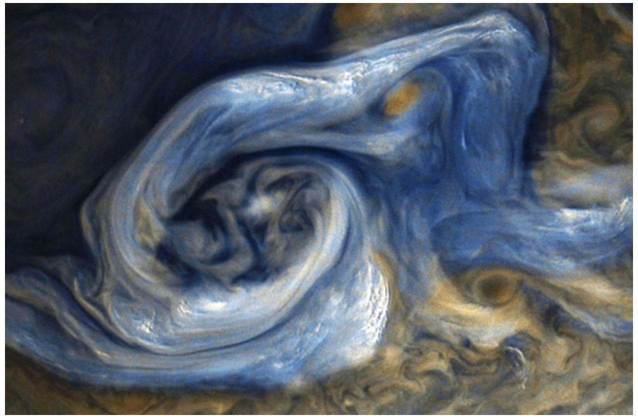
SCIENCE

National Aeronautics and Space Administration


COMMON THEMES IN PLANETARY SMALL BODIES RESEARCH (2018 UPDATE)

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Common Themes: What and Why?

- To help answer the question “Why so many missions to small bodies?”
- To provide a framework for goal-setting, white papers, and Decadal input.
- To help communication with the public and government stakeholders.

- First draft was shown to SBAG at June 2017 meeting.
- Input taken through informal discussions; thought and editing iterations at HQ.

- These slides show the text of the current version of the Common Themes document, ready to be declared “final” by PSD.
- A supportive SBAG finding could be helpful.

Formation of the Solar System

The collapse of the cloud of gas and dust that gave rise to our Solar System created myriads of individual bodies in a protoplanetary disk, each having a composition reflecting the conditions in the region where it formed. Most of these bodies were accreted into the major planets, but some of the remainder – transformed by solar radiation, mutual collisions, internal radioactivity, and encounters with the planets – became the populations of asteroids, comets, and other small bodies spread throughout our Solar System. Study of the compositions of these diverse objects, using telescopes, spacecraft, or by laboratory analysis of returned samples, collected meteorites, and interplanetary dust, contributes to our understanding of not only the comets and asteroids but also the origin of our Sun, Earth and Moon, and the other planets and their moons.

Formation of the Solar System

One-sentence version:

Study of the compositions of the asteroids and comets in our Solar System helps us to understand not only the objects themselves, but also the origin of our Sun, Earth, and Moon, and the other planets and their moons.

Evolution of the Solar System

Examination of the population of small bodies – their numbers, orbital distributions, masses and compositions – has led to the understanding that the Solar System has been a vast “mixing bowl”. The motions and gravity fields of the large planets have dispersed and then corralled many small bodies in orbital groupings in their vicinity, while other small bodies have been forced inward to the region of the terrestrial planets, shunted to outer regions, or ejected from the Solar System altogether. Studies of small bodies – measuring their orbits, distribution, chemical and physical properties – reveal the evolutionary history of the Solar System, showing how planets have migrated in their positions and the effects this has had on the early Earth, Moon, and other planetary bodies.

Evolution of the Solar System

One-sentence version:

Studies of the orbits, distribution, and physical properties of small bodies reveal the evolutionary history of our Solar System, including evidence for planetary migration, and the effects this evolution has had on the early Earth, Moon, and other bodies.

Delivery of Elements to Initiate and Sustain Life

Studies of returned Solar System samples, meteorites, and interplanetary dust, as well as telescopic and spacecraft observations of comets and asteroids, tell us that many small bodies contain water, essential to life on Earth, as well as organic compounds that may be necessary for life to originate. There is no evidence that life arose or exists today on any small body, but these ancient objects may have delivered water and organics to the early Earth, as well as to other planets and moons throughout the Solar System's history. Understanding the distributions of organic molecules, water, and other volatile compounds among the small bodies today can tell us how these materials formed in space, and how and when they may have been acquired by the planets.

Delivery of Elements to Initiate and Sustain Life

One-sentence version:

Understanding the distributions of organic molecules, water, and other volatile compounds among the small bodies can tell us how these essential materials for life formed in space, and how and when they may have been acquired by the planets.

Processes in an Active Solar System

Small bodies provide a window into physical processes that continue to shape our Solar System. Exploration of the largest asteroids in the Main Belt reveals dwarf worlds with active geology, which may be typical of bodies composed of both rock and ice. Images of the worlds beyond Neptune show that distant, icy bodies can have active cryospheres and atmospheres. Close study of Saturn's rings shows us small bodies in and near them that may be actively forming. The active surfaces of comets exhibit outbursts and breakups, along with complex geologic features arising from a combination of stresses. The moons of Mars, Deimos and Phobos, may be covered with material from the surface of Mars, ejected by ancient and/or more recent impacts. Thus, small bodies can help us to understand activity on and around larger bodies, and are more accessible for exploration than the surfaces of the major planets.

Processes in an Active Solar System

One-sentence version:

Small bodies provide a window into physical processes that continue to shape our Solar System, revealing clues to geological activity on and around larger bodies, while being more accessible for exploration than the surfaces of the major planets.

Hazards to Life and Human Populations

Near-Earth Objects (NEOs) are comets and asteroids that have been nudged by the gravitational influence of the planets, or collisions with other small bodies, into orbits that bring them into the Earth's vicinity. Some pose a potential impact hazard to Earth. Fully characterizing this hazard and the risk to human populations requires comprehensive discovery and determination of the precise orbits of these objects, as well as measurement of their sizes, compositions, and other physical properties. Understanding the physical characteristics of a potential Earth impactor will determine whether the consequences of impact are minimal, local, regional, or global, and will be critical to the design of any mitigation efforts.

Hazards to Life and Human Populations

One-sentence version:

Understanding the orbits and physical characteristics of objects that could potentially impact the Earth can help determine whether the consequences of impact may be minimal, local, regional, or global, and is critical to the design of mitigation efforts.

Resources for Exploration and Habitation into the Future

Mineral resources may be available in the small bodies for human or robotic explorers to use in space. Conceivably the most valuable such resource will be water. Water extracted from accessible near-Earth asteroids and comets could be consumed directly by astronaut explorers, or, using solar energy, could be dissociated into hydrogen and oxygen to fuel further exploration into the Main Asteroid Belt and beyond. Other minerals could provide raw material to manufacture tools and habitats for eventual human settlements off Earth, or even lay the foundation for a future space-based economy.

Resources for Exploration and Habitation into the Future

One-sentence version:

Mineral resources may be available in the small bodies for consumption by human explorers or for use in space for the construction of habitats and for further exploration.