Two clear themes therefore emerge as basic to study of the primitive bodies of the solar system:

Primitive bodies as building blocks of the solar system, and

The origins of organic matter that led to life on at least one planet.

Primitive bodies as building blocks of the solar system

Where in the solar system are primitive bodies found, and what range of sizes, compositions, and other physical characteristics do they represent?

What processes led to the formation of these objects?

Since their formation, what processes have altered the primitive bodies?

How did primitive bodies make planets?

How have they affected the planets since the epoch of formation?

The origins of organic matter that led to life on at least one planet.

What is the composition, origin and primordial distribution of solid organic matter in the solar system?

What is its present-day distribution?

What processes can be identified that create, destroy, and modify solid organic matter in the solar nebula, in the epoch of the faint early Sun, and in the current solar system?

How did organic matter influence the origin of life on Earth and other planets?

Is organic matter similarly distributed among primitive bodies in other planetary systems?

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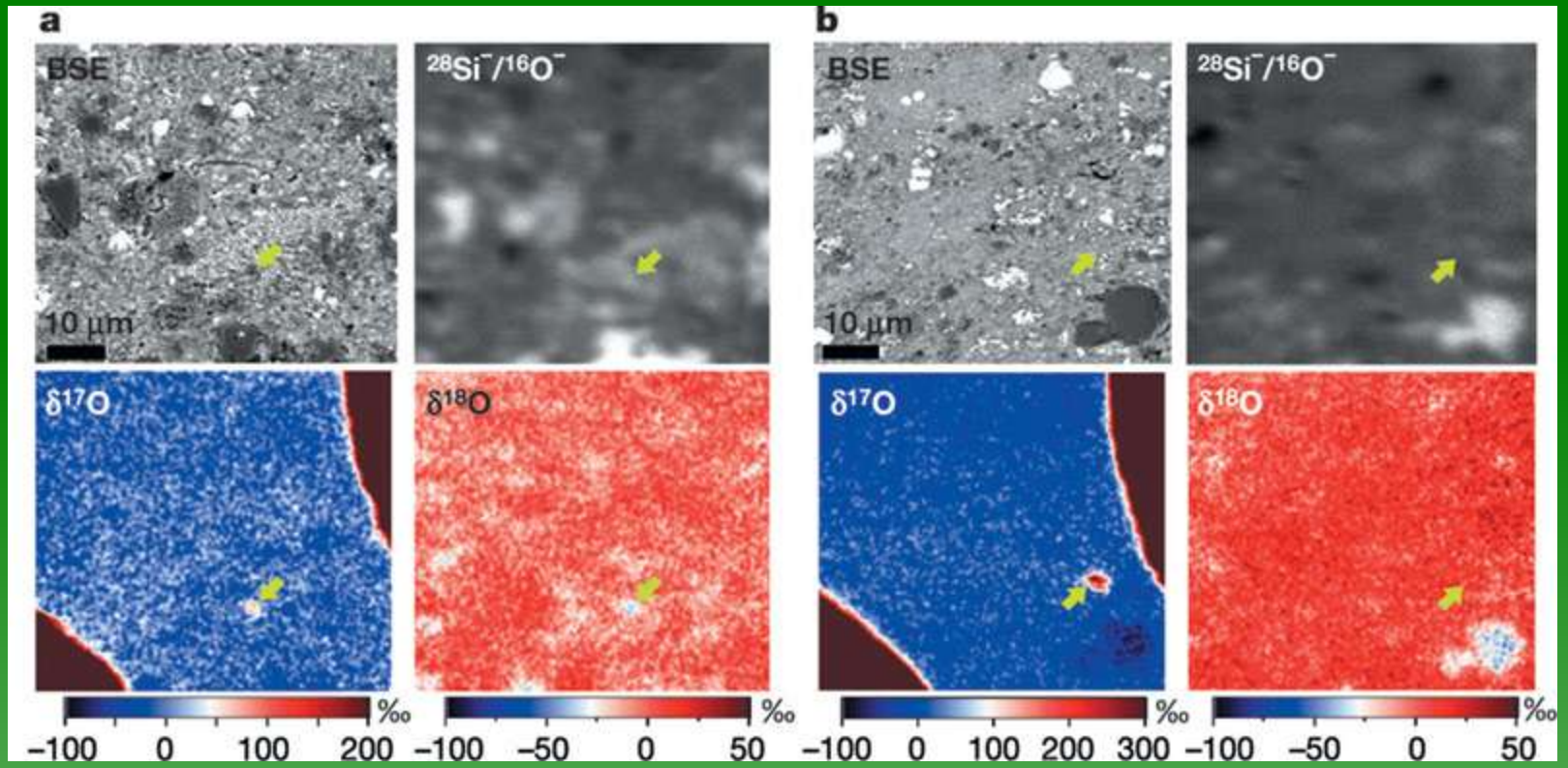
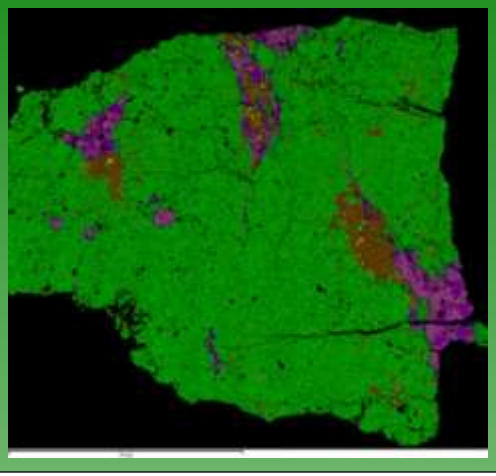
- Primitive bodies record epochs of time and processes whose record has been erased from or is obscured in planets
  - Stellar processes recorded in presolar grains
  - Nebular condensation
  - Processing in the early solar nebula
  - Planetary accretion
  - Early aqueous alteration
  - Early melting and differentiation
    - Planetary cores

- Non-mission materials discoveries
  - Presolar silicates (Messenger et al., 2003)



Nagashima et al., 2004

- Non-mission materials discoveries
  - Presolar silicates (Messenger et al., 2003)
  - Diverse presolar grains (Wash U and U-ites)
  - Time scales <1 Myr at 4.56 Byr routine
  - Acceptance of nebular shock as a chondrule-forming mechanism
  - Nature of organics (e.g., chirality) influenced by aqueous alteration
  - GRA 06128/129 meteorites as samples of the crust of an oxidized, differentiated asteroid



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  - Spectoscopic studies linking asteroids-meteorites (e.g., CAI-rich, basaltic, FeO-rich olivine-rich)
    - 2008 TC3 and Almahata Sitta

- Materials R&A
  - Cosmochemistry (flat)
  - Origins (flat)
    - Negative impact on new starts/grad students
  - SRLIDAP/LARS (new since last Decadal)

Funding opportunities outside small bodies

- ASTEP
- LASER
- MFRP
- Astrobiology
- Missions (MER, MSL, Dawn, LRO, MESSENGER)

- Primitive bodies missions
  - Kuiper Belt-Pluto explorer
  - Comet Surface Sample Return
  - Trojan asteroid/Centaur recon
  - Asteroid lander/rover/sample return
  - Triton/Neptune flyby
  - Comet cryogenic sample return

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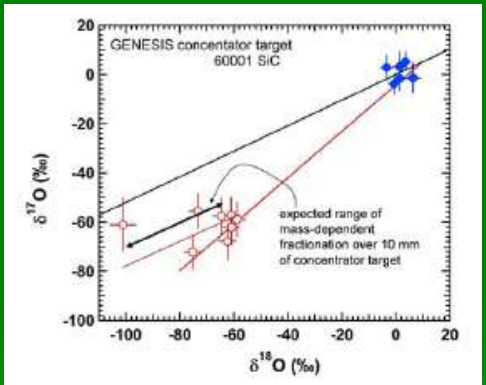
- Primitive bodies missions
  - Kuiper Belt-Pluto explorer
  - Comet Surface Sample Return
    - Permitted under New Frontiers call
    - At least 1 proposal submitted
  - Trojan asteroid/Centaur recon
  - Asteroid lander/rover/sample return
    - Permitted under New Frontiers call
    - At least 2 proposals submitted
  - Triton/Neptune flyby
  - Comet cryogenic sample return
    - No significant progress toward this goal

- Primitive bodies missions – Discovery
  - Deep Impact
  - Genesis
  - Stardust
  - EPOXI
  - Stardust-NEXT
  - Dawn

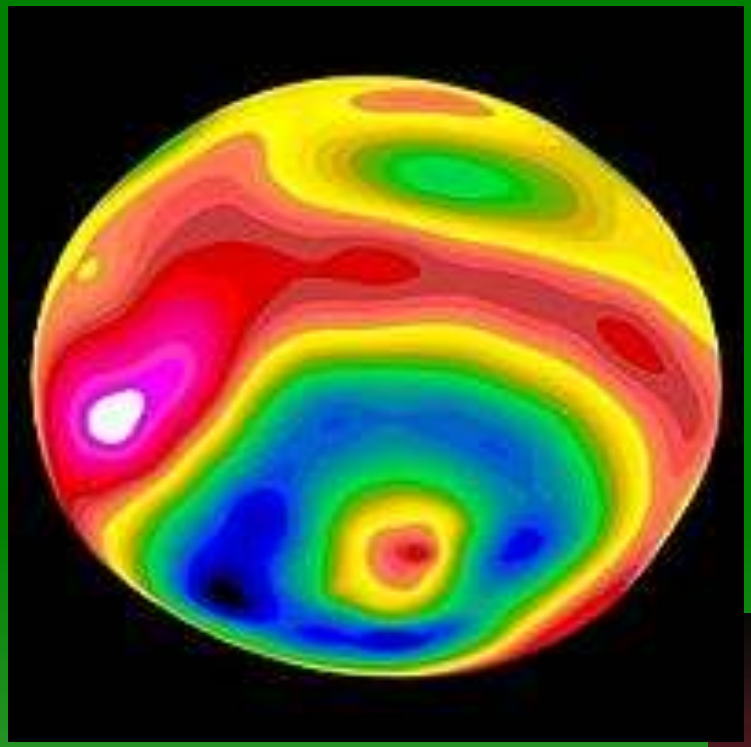
- Primitive bodies missions – Foreign
  - Marco Polo asteroid sample return
  - Hayabusa asteroid sample return
  - Rosetta – comet lander/asteroid flyby
  - Phobos-Grunt – asteroid sample return

- Primitive bodies missions – Discovery
  - Genesis
    - **The data are in semi-quantitative agreement with expectations based on models of chemical and isotopic evolution of oxygen in the solar nebula or its precursor cloud by isotope-selective photochemical self-shielding of CO**



  - Stardust
    - **The relatively low abundance of such presolar grains in cometary samples could be explained by extreme dilution with presolar-grain-free matter from the hot inner solar system, but this opens many new questions about mechanisms of transport and mixing in the solar nebula**

- Primitive bodies missions – Discovery
  - Dawn



- Primitive bodies enabling technologies
  - Cryogenic sample preservation and handling
    - Laboratory equipment
    - Relatively little progress – no impetus
  - Remote age determination
    - Dependent on those with lab experience
    - Several proposals have been floated
  - Nuclear-electric propulsion
    - Opens up a wider range of possibilities

- Primitive bodies supporting facilities
  - Near-Earth Objects
  - Earth-based telescopes
  - Planetary radar facility
  - IRTF
  - Keck
  - Laboratory facilities for returned samples
    - SRLIDAP/LARS
  - Curatorial facilities
    - Greatly expanded – Genesis, Stardust
    - At the expense of older collections?