Surface refugia on Mars?

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Dark Dune Spots (DDSs): a candidate habitat (2001)?
Analyzed DDS sites in the south polar region (Mars Global Surveyor data)

MOC images
Dark dunes

Malin Space Science Systems
DDSs stick to the dunes...
...and have inner structure
The most detailed source

DARK DUNE SPOTS: POSSIBLE BIOMARKERS ON MARS?

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1. Significant amount of surface water ice in the south polar region
2. Frost/ice in the polar region is layered (water at bottom, CO$_2$ at top)
3. Transient melting on the surface of the dark dunes, causing
4. Flows from DDSs on slopes
5. Summer phantom DDS images
Simple frosting-defrosting does NOT work, because…

Spot formation begins at the bottom, not at the top!
Simple frosting-defrosting does NOT work, because...

Spots do *not* develop on exposed sites!
Simple frosting-defrosting does NOT work, because…

There is annual recurrence (>75%) at the same sites!
Simple frosting-defrosting does NOT work, because…

- On slopes flows originate from the DDSs
- Which always flow downwards
- From elongated spots
- Gravitation is a formative cause
Flows may be due to water runoff

- The dry planet is much wetter than thought
- There is plenty of water:
  - In both ice caps
  - In the upper layer of the polar region (permafrost)
  - In liquid form in the gullies
Clow’s (1987) model for melting

- Melting occurs beneath the surface at temperatures well below freezing, because sunlight is absorbed at depth rather than at the surface, and this absorption is substantially increased by the incorporation of minor amounts of dust.

- Can occur for a wide range of snow properties and atmospheric pressures, and occurs under current conditions in mid-latitudes if dust abundances are greater than 1,000 parts per million by mass.
The effect of salinity on the melting point of water

Martian surface temperature cross melting thresholds of several brine systems expected on Mars

Models of diurnal temperature cycles courtesy of the MER teams: NASA/JPL/Cornell

H₂SO₄-HCl-H₂O gives even colder eutectics
Yearly recurrence of seepage

A strictly localized phenomenon
Layered frost on the dunes (2002)

- Water ice, clathrate, and CO₂ ice are deposited in that order.
- Dunes are the first to frost and the last to defrost.
- Total frost between 0.2-1 m (laser altimeter).
Dark spots are transformed to summer phantom spots
The biological hypothesis

- Annual reactivation and growth of photosynthetic organisms
- Ice: excellent shield against cold, UV and dryness
- Organisms must go to dormancy before water ice shield melts through ('adaptive sporulation')
Looking for partial analogues on Earth (extremophiles)

- The Dry Valleys of Antarctica
- Cold, dry
- High UV due to continuous solar exposure
- Ozone depletion
Photosynthetic microorganisms

At the centre of a rich consortium
Candidate analogue organisms

- Multiply extremophilic organisms
- Blue-green algae (cyanobacteria)
- Halobacteria
- Ecological consortia
- Another example: the cryptobiotic crust
Summary

- DDSs are a potential habitat for life on Mars today
- They may be actual habitats
- Earthly analogues are encouraging
- Chamber simulations have to be carried out
- Looking for pigments with appropriate spectroscopy (resolution, wavelengths!)
- Sending landers to interesting sites!