Potential for Microbe Colonisation of Mars by rocks launched into space during the Chicxulub impact

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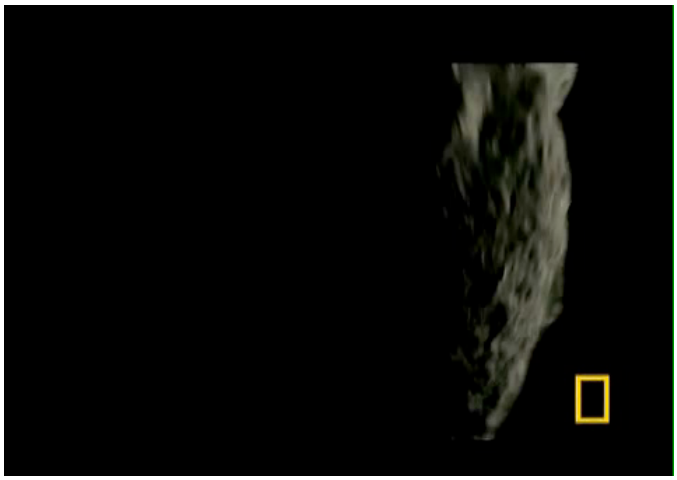
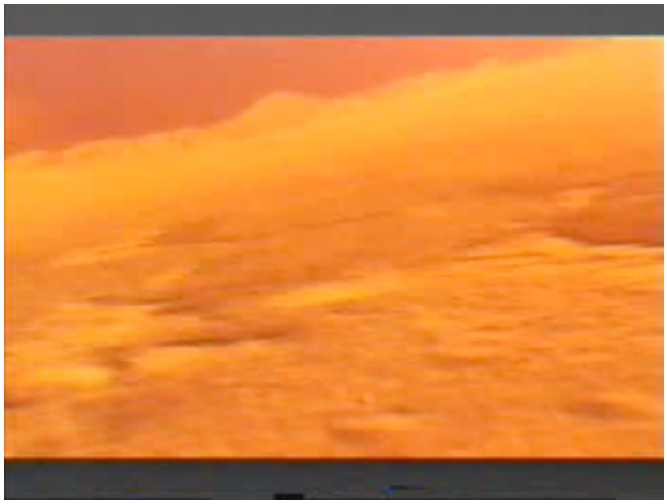
The Chicxulub Impact

- 65 million years ago the Chicxulub impact in present-day Mexico caused notable extinctions on Earth but it also threw 100s of millions of tonnes of Earth rock into outer space.
- Could some of these rocks have reached Mars with living microbes?



Earth rocks reaching Mars

Meteorites from Mars have reached the Earth under conditions that would enable *hypothetical* hitchhiking microbes to survive.



Similarly, rocks ejected by large impacts on Earth must have reached the surface of Mars

It has been estimated that, each year, about about 500kg of "unsterilized" Earth rocks from the Chicxulub impact reaches the surface of Mars

Perils of the journey

- The **shock wave** generated by the initial impact heats nearly all of the target rocks to 1000s of degrees - BUT Martian rocks have been ejected without heating - the famous ALH84001 Mars meteorite was not heated over 40C. The mechanism, explained by Jay Melosh, is a little like crumbs being flicked off a picnic blanket.
- The **10,000g acceleration during launch** would kill any large organisms - but Swedish researchers have fired bacteria out of a cannon and most survived accelerations of 30,000g.

Perils of the journey

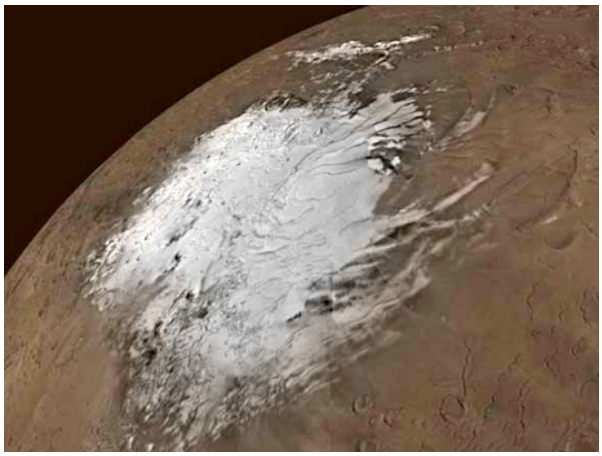
- The **cold, vacuum and radiation of space** would also kill large organisms - but half a metre of rock effectively shields against the radiation. Freezing conditions and vacuum can help survival of microbes or spores.
- During re-entry most large meteoroids **explode in a fireball** - but many chunks survive to reach the planetary surface.
- **Heat of re-entry** usually melts the crust of a meteorite. However the insides stay frozen.

500kg of Chicxulub rocks reaches Mars each year

It has been estimated that 15% of this reaches the surface of Mars with surviving microbes, meaning about 75kg reaches the surface of Mars each year. The equivalent of one frozen astronaut each year!

Barriers to Colonisation

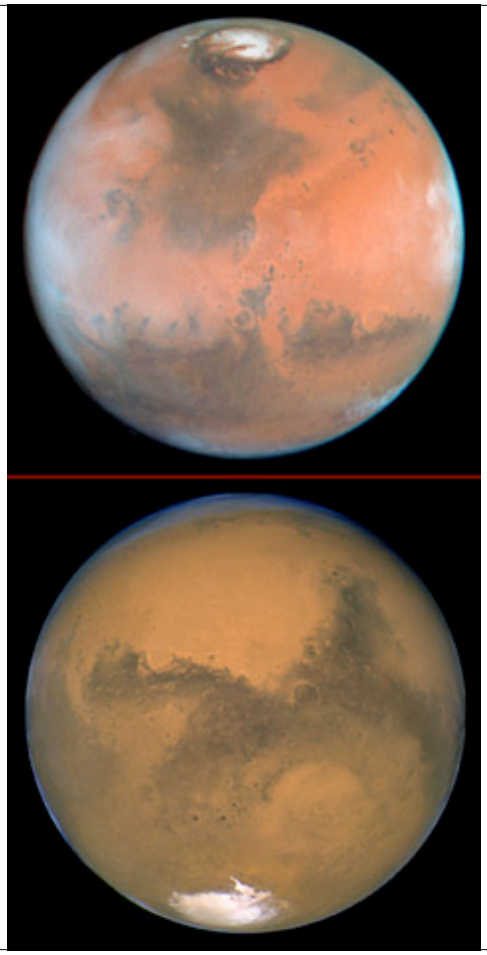
- Even if an Earth rock with microbes reaches the present day surface of Mars conditions are not good for colonisation by "normal" microbes. Extremophiles hold out more hope.
- Icecaps or glaciers give more chance for Earth life establishing on Mars.



Ice on Mars

North & South Ice Caps total

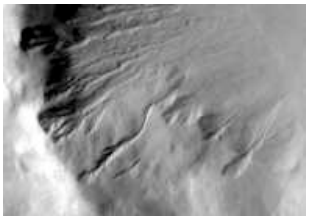
880,000 sq km = 0.61% of total surface area of Mars



Ice on Mars

43,000 craters > 5km diameter. Assume 5% have ice then about 170,000 sq km = 0.12%

Therefore some 0.73% of Mars surface is ice



Liquid water on Mars

"there are several sets of parameters which will lead to development of layers of liquid water just below the top surface of snow- and ice-packs on Mars. This at least partial liquefaction occurs repetitively (e.g. diurnally, seasonally), and can in some cases lead to liquid water persisting through the night-time in the summer season." (Möhlmann 2010) - a greenhouse effect

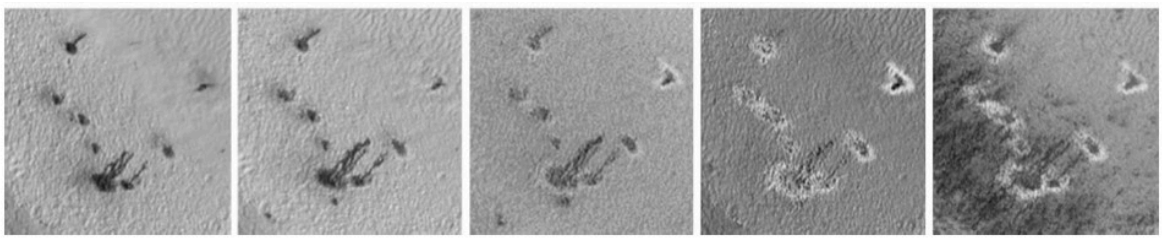
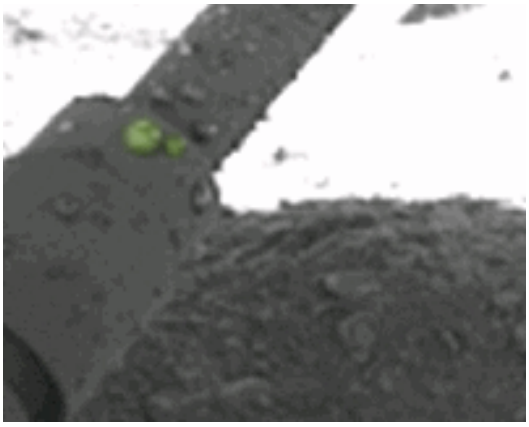


Fig. 5. "White collars", evolving at springtime around dark spots at three locations in the Richardson crater at 72°S, 180°E (HiRISE images from left to right Nos. 3175, 338(3597, 3742, 3953 corresponding to L_s of 210.6, 220.7, 230.9, 238.1, 248.5) (taken from Kereszturi et al. (2009)). *Möhlmann / Icarus 207 (2010) 140–148*

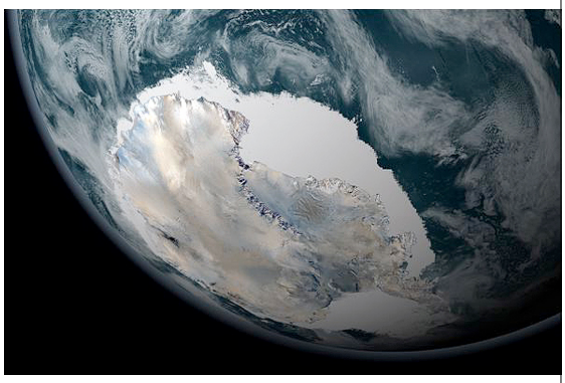
Liquid water on Mars

Phoenix mission recorded cryo-brine water droplets forming on the spacecraft



Liquid water on Mars

- Using Antarctica as an analogy, 12% of Mars surface ice would be exposed to sufficient sunlight to melt sub-surface ice during summer
- Assuming melting takes place for 2 months per year then, on average, 2% of surface ice is melted just below surface
- 2% x 0.73% = 0.015% of Mars surface area has liquid water just under the surface of ice



Landing in Liquid Water

- Our 75kg of rock has a 0.015% chance of landing in liquid water
- An average of 11grams of rock per year
- 11g of Earth rock typically contains 100 million microbes

Landing in Liquid Water

- 11g per year means one truck load every 2 million years

Landing in Liquid Water

That's 32 truckloads since the Chicxulub impact!