ASTEROIDS: NOW FOR THE GOOD NEWS

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Introduction

The danger to life on Earth from asteroids and comets (Near Earth Objects - NEOs) has been firmly established - major impacts are rare but deadly events

Even small impacts are a threat to civilisation (annual risk of 50Mt airburst about 1 in 5000).

The Good Side to NEOs

- They deliver, to the surface of planets, many of the raw materials necessary for life.
- They are a source of raw material for space-faring civilisations
- They provide a mechanism for exchange of life between planetary surfaces
- Impact craters can provide unique habitats for hardy lifeforms

I will be talking about the last two items

Interplanetary Hitchhikers?

- Paul Davies, amongst others, believes there is a strong chance that microbes have ridden aboard meteoroids travelling between Earth and Mars - “Transpermia”.
- It is likely that Earth-life has reached Mars. The reverse is possible (are we really Martians?)
- Possibly also a “lifeboat” (escape pod) for ancient life to ride out a surface-sterilising event and return when things “cool off”

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 ALH8400 Mars meteorite was not heated over 40C. The mechanism, explained by Jay Melosh, is 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

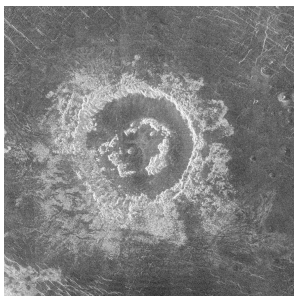
- The **cold, vacuum and radiation of space** would also kill large organisms - but half a metre of rock effectively shields against the radiation. Freezing conditions and vacuum can help survival of microbes or spores.
- During re-entry most large ones **explode in a fireball** - but a good fraction of large meteorites survive to reach the Earth's surface. **Heat of re-entry** usually melts the crust of a meteorite and. After they land meteorites are often are observed to have a layer of frost because the interior stays at -40C during re-entry

Mars rocks reaching Earth

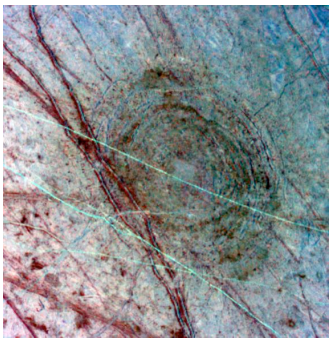
- Meteorites from Mars have reached the Earth under conditions that would enable hypothetical hitchhiking microbes to survive.
- Averaged over millions of years, about 500kg of Mars rock reaches Earth per year.
- The rate of transfer of material under favourable conditions is equivalent to sample return missions bringing 10kg of surface material from Mars to Earth every year (but the flux is highly variable)

Possible Limits to Transpermia

So far no meteorites have been found on Earth that have been shown to originate from either Earth or *Venus* - maybe there are gravitational or atmospheric impediments?



The Moon and *Europa* have no atmosphere - collisions occur at interplanetary speeds and most of the meteoroid is vaporised in the impact.



(NASA)

Possible Limits to Transpermia

- 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.

(NASA)

Possible Limits to Transpermia

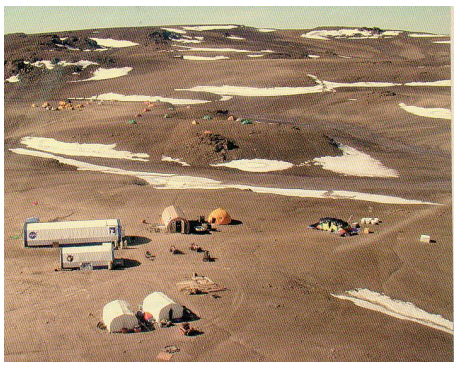
- Jay Melosh estimates that, during the age of the solar system, only a handful of Earth rocks have ever reached another stellar system. Then only 1 in 10,000 chance of reaching a solid planet

- In any case, transit times are 100s of millions of years

- Unlikely to be a mechanism for “panspermia” (transport of life between stellar systems).

Craters as cradles of life?

- Haughton Crater on Devon Island, Canada, is being explored as a Mars analogue.



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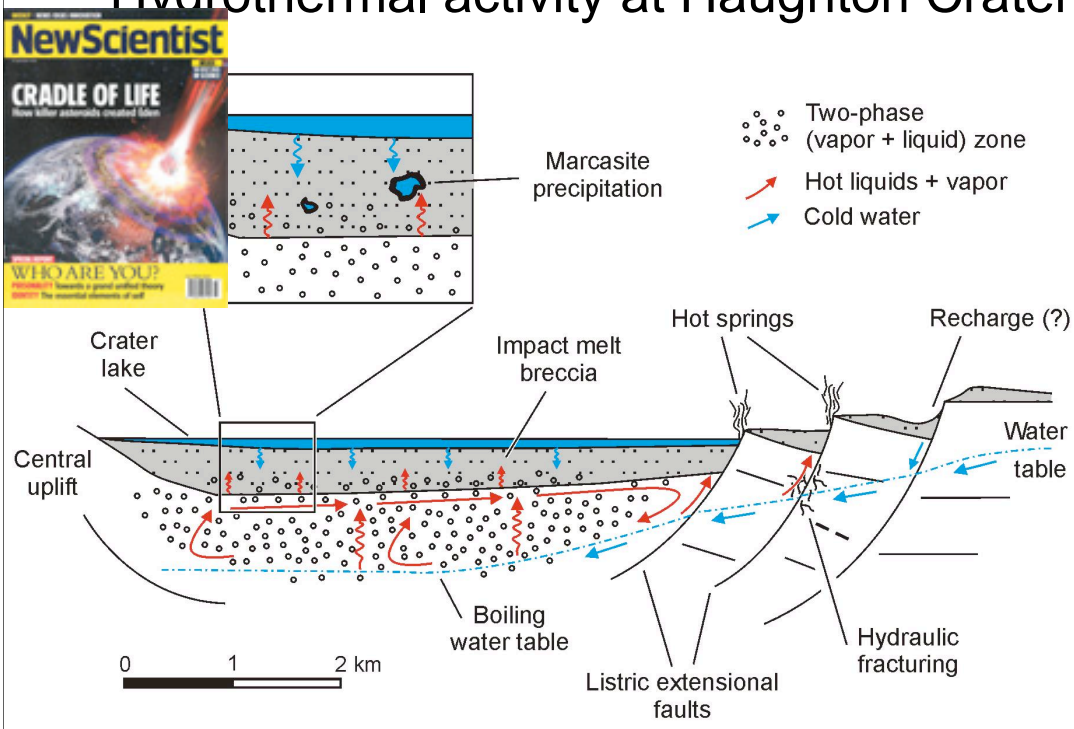
Craters as cradles of life?

- NASA scientists have found dormant hydrothermal systems caused by the Haughton impact event

(Osinski

Hydrothermal activity at Haughton Crater



Note the hot springs on the rim of the crater

(Osinski

Craters as cradles of life?

- Extremophile lifeforms thrive in active hydrothermal systems on Earth
- Haughton short-lived?

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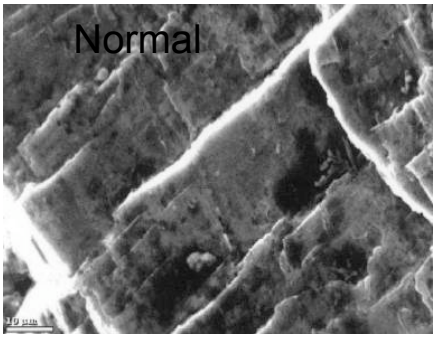
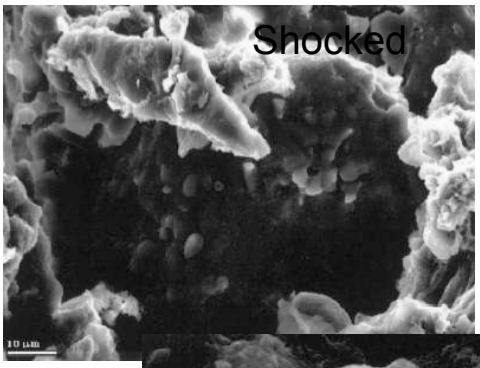
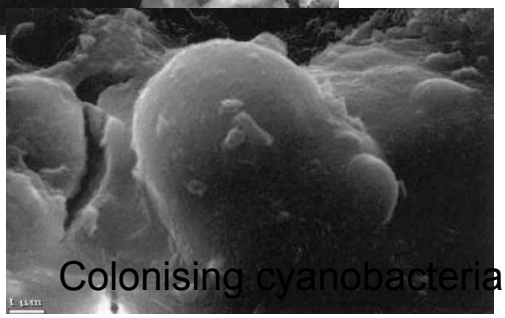
Craters as cradles of life?

- Shocked rocks from the impact provide a rare habitat for cyanobacteria







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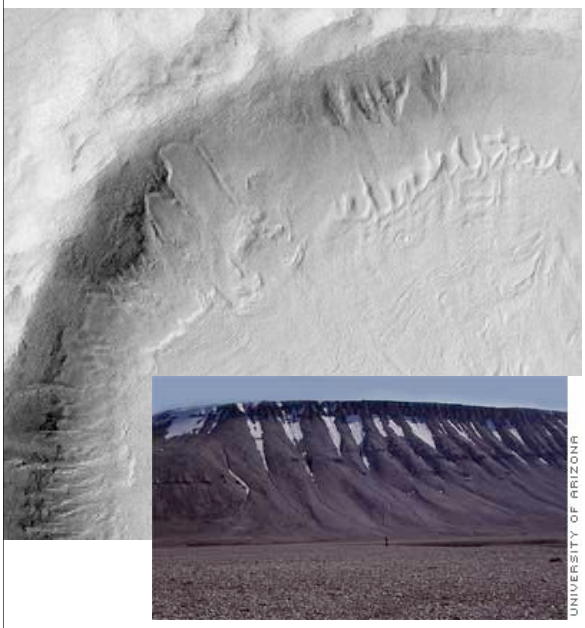
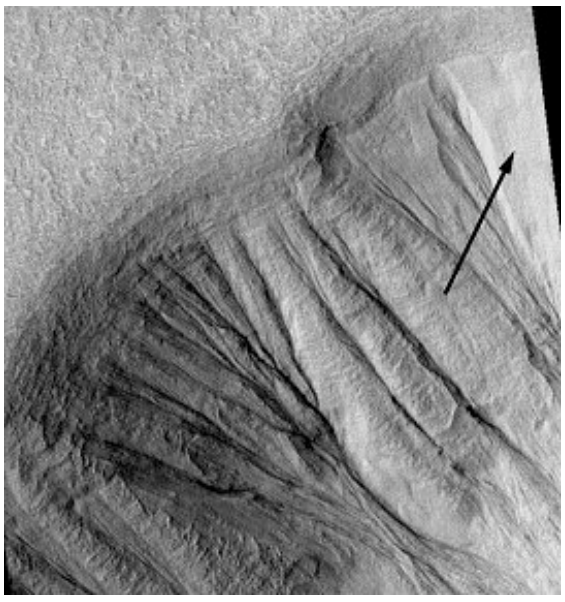
Craters as cradles of life?

- Possible signs of past (recent?) liquid water in the craters of Mars. Maybe a trap for snow?



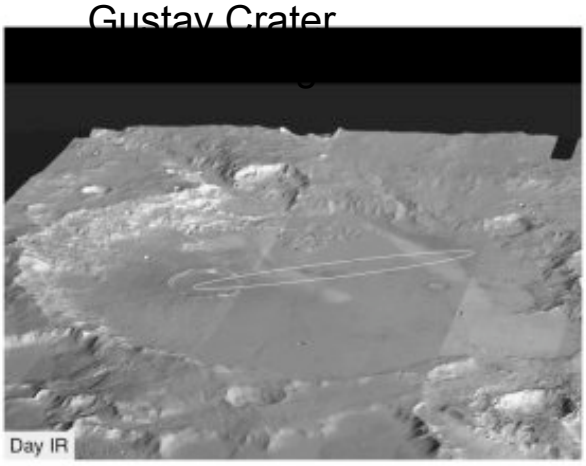


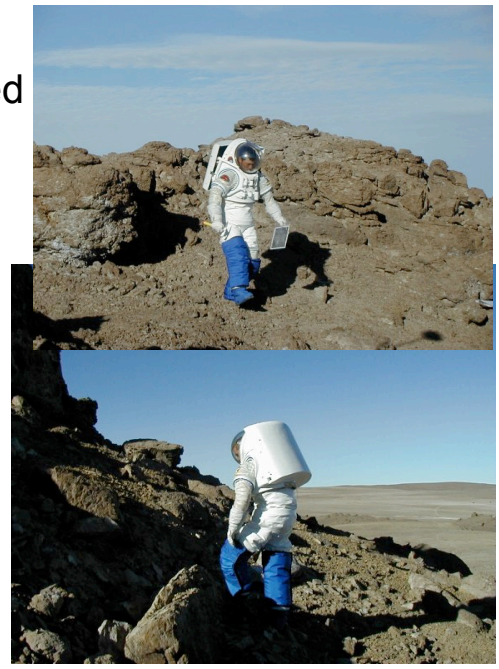
(NASA/Christensen)

Craters as cradles of life?

- Maybe craters are a good place to look for life on Mars?
- Major impacts may have caused torrential rain that formed the valleys of Mars.

Gustav Crater





(NASA/Lee/Osinski)