Permanent infecting of the Venus upper atmosphere by transfer of terrestrial microorganisms through the ejected dust particles from the Earth and Mars.

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Venera-D Joint Science Definition Team Workshop:

Potential Landing Sites and Cloud Layer Habitability

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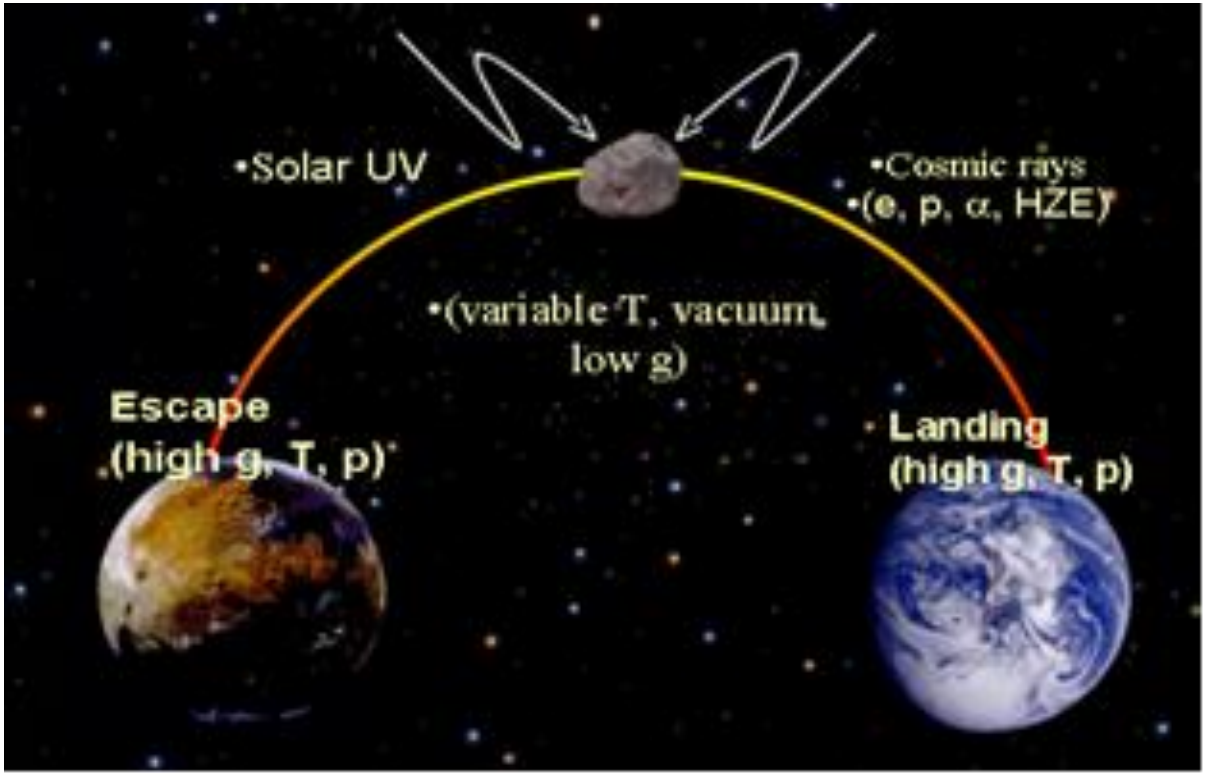
Panspermia in Solar System.

Hypothetical way of terrestrial microorganisms transfer trough the interplanetary space and full number of harmful factors which biota should have experienced.



Astrophysical key points

- There are a lot of large impact craters on Mars and Earth
- There is permanent exchange of a planetary surface material between terrestrial planets. Approximately 500 millions of the meter-sized unsterilized martian meteorites arrived on the Earth during $4 \cdot 10^9$ years and 500 thousand bodies arrived from Earth to Mars.
- But, large size planetary meteorites can't infected upper atmosphere of Venus

Hypothetical way of the upper atmosphere infecting

- Large meteorite impact on Earth or Mars
- Ejection of dust particles with microorganisms to space
- Slow drift of micron-sized particles to Sun
- Capture of dust particles by Venus without extremal heating at entry into upper atmosphere
- Small-size dust grains with microorganisms slowly drop and stay in dense atmospheric layers

continue

- Each impact generate the numerous number of high speed micron-sized particles and significant part of them are ejected to space.
- After escape the dust particles move around the Sun on circled orbits and they have a slow drift to Sun due to the classical Poynting-Robertson effect.
- The Poynting–Robertson drag can be understood as an effective force opposite the direction of the dust grain's orbital motion, leading to a drop in the grain's angular momentum. The dust grain thus spirals slowly into the star.

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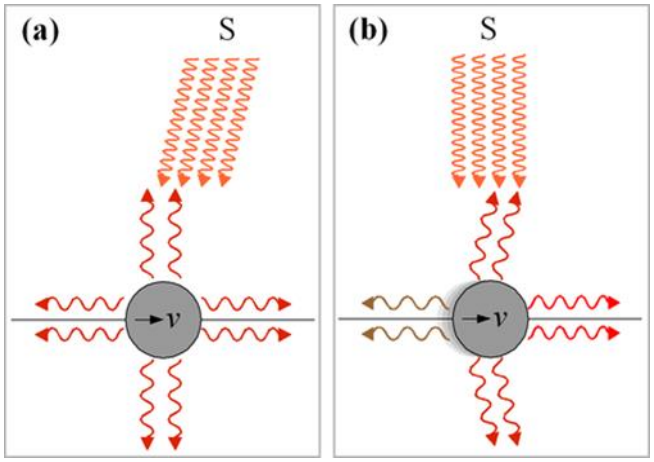


- Radiation from a star (S) and thermal radiation from a particle seen (a) from an observer moving with the particle and (b) from an observer at rest with respect to the star.
- $t_{P\text{-}R}=400R_{AU}^2/\beta \rightarrow 10^3\text{-}10^4$ years Earth→Venus
- $\beta=F_r/F_g$ - is the ratio of the solar radiation force to the Sun's gravitational attraction, $\beta \sim r_d^{-1}$ for $r_d>1\mu m$

Capture

- Cross-section of dust capture by planet: $S=\pi R^2(1+V_{esc}^2/V_\infty^2)$

→ large cross section for dust grain with circled orbits ($V_\infty \rightarrow 0$)

→ There is the permanent transfer of planetary dust material from Earth and Mars to Venus

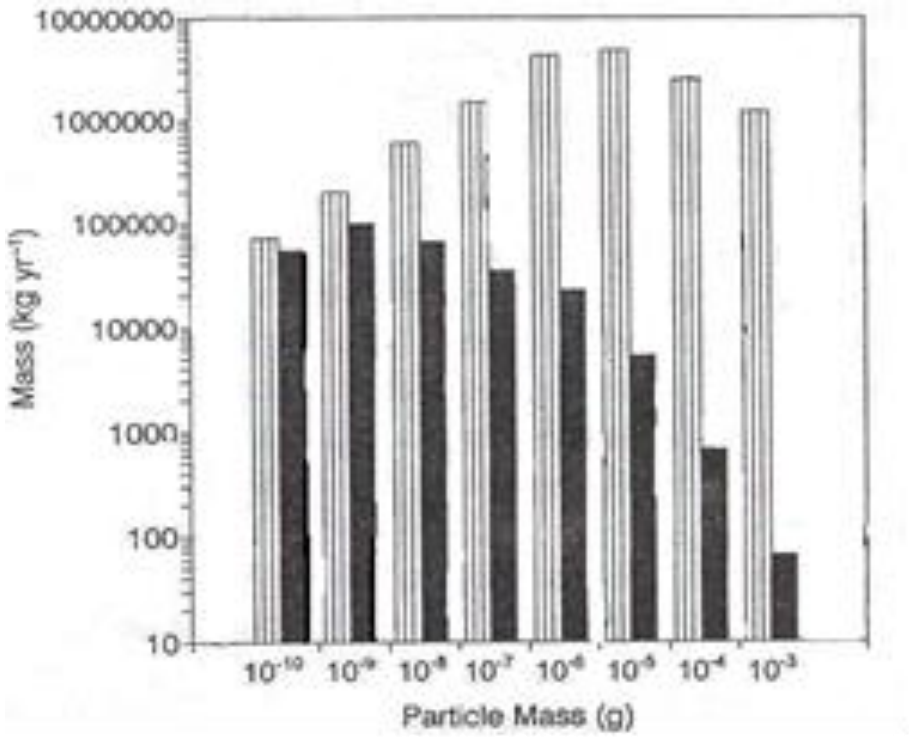
Sterilization factors

- Heating in the large impact process
- Heating of high velocity dust grains in process of entry in the Venus atmosphere (100-1500°C)
- Vacuum drying in space
- Solar UV radiation
- Solar wind ions bombardment
- Cosmic rays radiation

Heating

- There are at least five nakhlites and ALH84001 did not experience sterilizing temperatures during ejection from Mars and entry into the Earth's atmosphere (Shuster and Weiss, 2005) → part of ejected debris are not sterilized during the ejection
- Dust particles with tangent entry into atmosphere are not heated more 200-300°C and time of high temperature pulse 10<t<50sec (Flynn 1989 year)
- Bacteria survive at temperature 250°C during 30sec at low atmospheric pressure (Pavlov et al., 2007 year)

Total mass incident on the top of atmosphere (from *Love and Brownlee*, 1993) in each mass decade (striped) and mass that is not heated above 600º C.

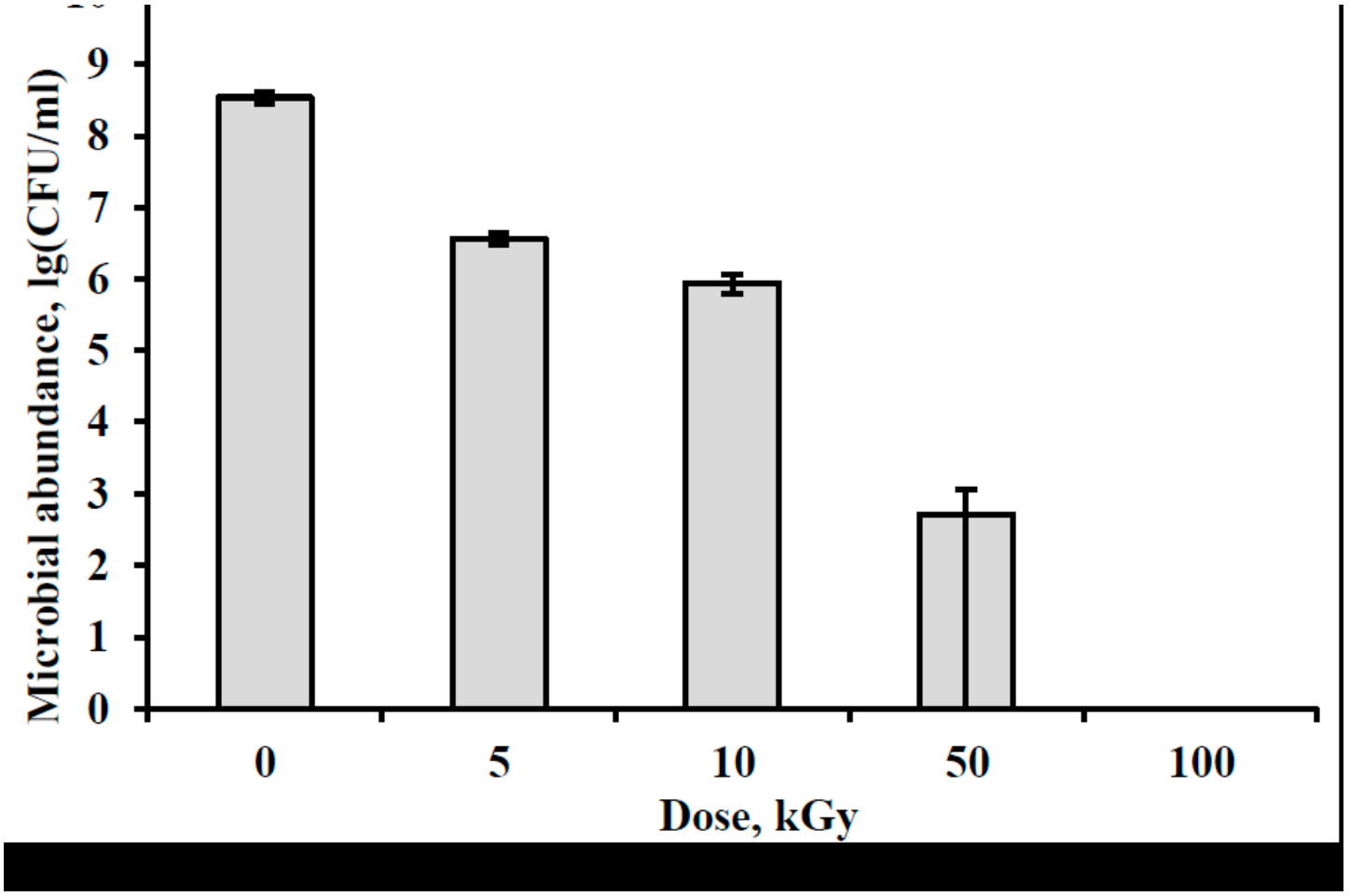


Vacuum, UV and solar wind

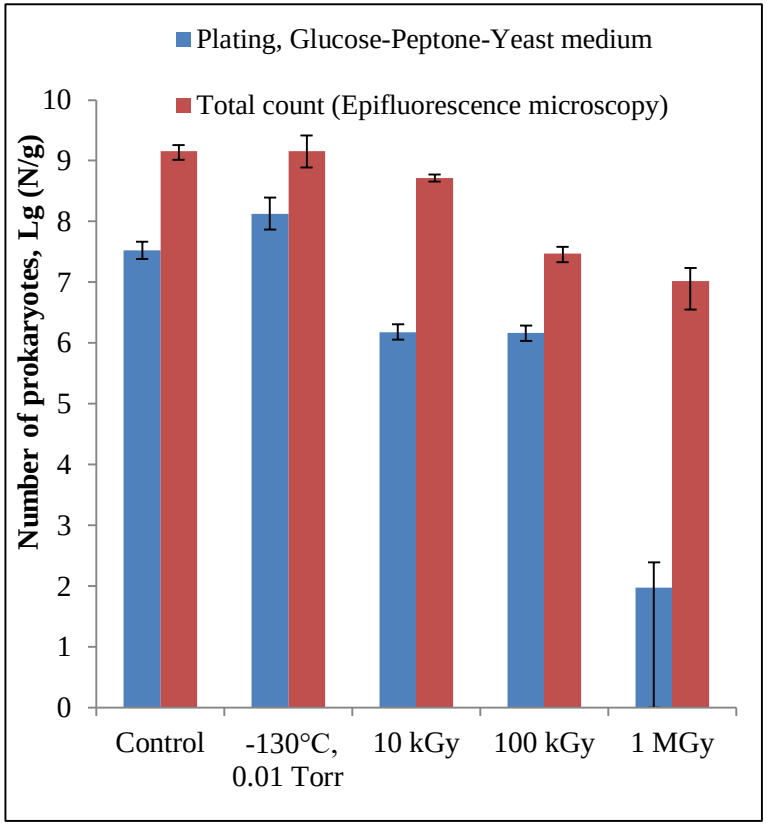
- Several space and laboratory experiments have demonstrated a presence of viable microorganisms after long period of the vacuum impact
- UV – surface sterilization only
- Solar wind effect – d<0.1µm
- Critical factor is solar cosmic rays with E_p>1MeV

Dose rate 0.1 Gy/a → 1-10 kGy during space travel

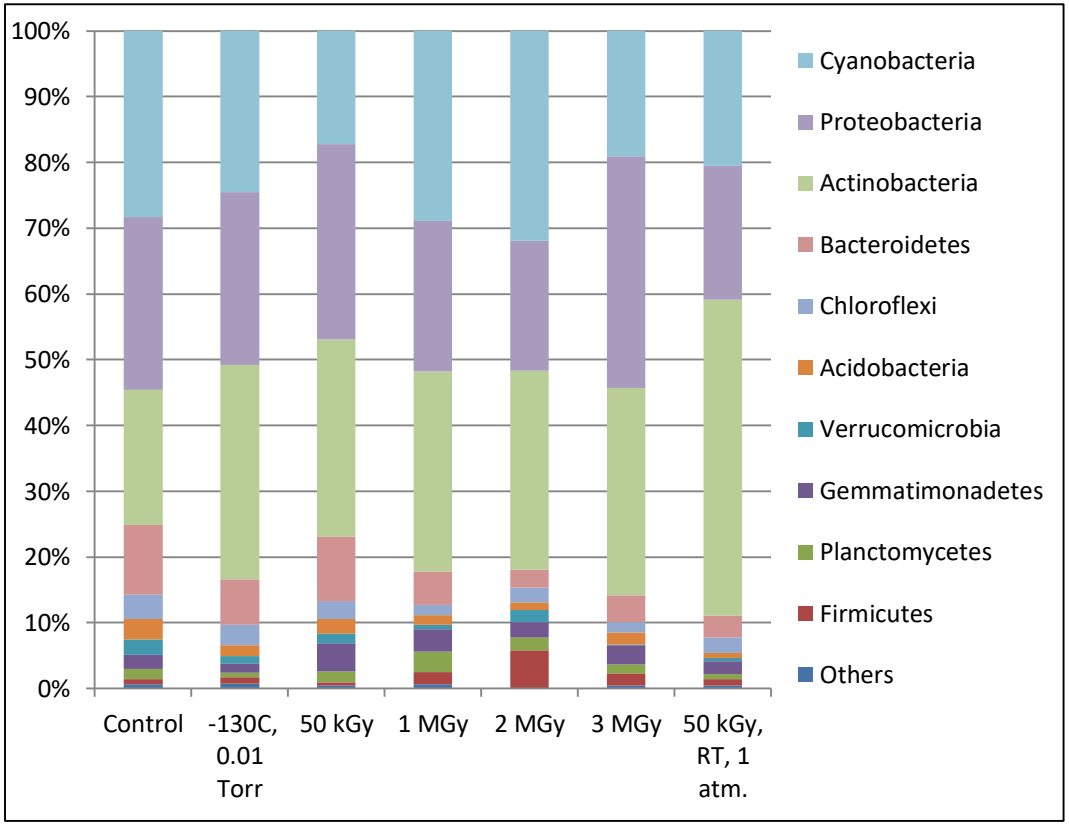
Impact of high energy electrons irradiation on the number of *Deinococcus radiodurans VKM* B-1422T viable cells.



Impact of irradiation with accelerated electrons (~1 MeV) under low temperature (-130°C) and low pressure (0.01 Torr) on viability of soil and permafrost microbial communities



Prokaryotes count in desert soil



Permafrost bacterial community by 16S rRNA Illumina sequencing

Cultured bacteria were detected after irradiation with doses up to 1 MGy, biomarkers (DNA, lipids) - after irradiation with doses up to 3-5 MGy.

Conclusions

- There is the permanent process of microorganisms transfer from Earth to Venus by small size dust grains which are generated by the meteorite impacts
- The same process could be realized for hypothetical Martian biosphere with much more intensity
- Part of planetary dust particles are not sterilized before injection into the upper atmosphere of Venus
- As result, life could be in the cloud layer of the Venus atmosphere if terrestrial microorganisms are able to adapt to such environments.