

Investigating the Viability of Microorganisms in a Venus **Cloud Analog**

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Adapted from JAXA







Where do we believe life could exist?







What makes us think life could exist there?





What makes us think life could exist there? The absorbers.





What candidates have been proposed since the first **Observation?** Sulfuric acid, Young, 1973 Elemental sulfur, Hapke and Nelson, 1975 Hydrobromic acid, Sill, 1975

Nitric oxide. Shava and Caldwell. 1976

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Absorbers first observed by Frank E. Ross from Mt. Wilson.



Absorbers have remained a mystery.

Could the absorbers be life?









Hydrated FeCl3, Kuiper 1969



Life can survive in extreme conditions.





Life can survive in the clouds of Earth.



Jane Peterson/NASA



What are the Venusian cloud conditions?

Altitude of 47.5 km to 50.5 km Temperatures average ~60°C High levels of UV radiation Terrestrial-like pressures Highly acidic environment (sulfuric acid)



Goal: Determine if the absorbers are life.





How can we determine if they are life?



Determine viability of microorganisms in Venus cloud conditions Identify genes responsible for their adaptation/survival





How can we recreate Venus cloud conditions?



Glenn Extreme Environments Rig Glenn Research Center



Biotron Laboratory University of Wisconsin, Madison



What conditions will be used?



How have the microorganisms been selected?

Potentially survive in temperature of ~60°C

Acidic environment

Ability to oxidize sulfur and fix carbon dioxide

Logistics

Evolutionary relatedness





FIG. 2.10. Phylogenetic tree of domain Bacteria showing the major lineages.



Woese, 1987

Ancient Venus possibly had oceans and storm clouds.









Evolutionary time scale also taken into consideration.







What are some potential terrestrial microorganisms?







Acidithiobacillus genus pH = 1-3.4 $T = 25 - 45^{\circ}C$

Thermotoga genus pH = 5.4 $T = 70 - 80^{\circ}C$

Rhodophila globiformis pH = 4.2 - 6.5 $T = 30^{\circ}C$

Sulfuriferula multivoran pH = 5.3 - 8.6 $T = 8 - 32^{\circ}C$

Stygiolobus pH = 2 $T = 80^{\circ}C$ Acidobacteria capsulatum pH = 3.6

Crenarchaeota phylum pH = 2-4 $T = 80^{\circ}C$

Thermosulfidibacter takaii pH = 5-7.5 $T = 55 - 78^{\circ}C$

Acidianus genus pH = 0.8 - 1.4 $T = 45 - 83^{\circ}C$

Green Sulfur Bacteria







What genes are responsible for their viability?

DNA



RNA





Protein

Translation

Transcription

What is RNA-sequencing?





Investigate viability of microorganisms in aerosolized form.





Investigate viability of microorganisms in aerosolized form.

Compare genetic profile of multiple generations.



major.histocompatibilit
Purinergic.receptor..fan
butyrophilin..subfamily
Homo.sapiens..beta.2.n
nuclear.transcription.fa
transcription.factor.4
major.histocompatibilit
retinoic.acid.receptor.re
ladinin.1

Human.calcium.channe butyrophilin..subfamily interleukin.6..interferoo disabled..Drosophila..h P311.protein peroxiredoxin.2 arsA..bacterial..arsenite NK.cell.triggering.recep proteasome..prosome.. hepatitis.C.associated.r Human.Tis11d.gene beta.2.microglobulin SRY..sex.determining.ro

low.density.lipoprotein. proteasome..prosome.. mitogen.activated.prote jumonji..mouse..homolsmall.inducible.cytokintumor.necrosis.factor..l major.histocompatibilit granzyme.A.

small.inducible.cytokine synovial.sarcoma..trans angiotensin.receptor.lik guanylate.binding.prote natriuretic.peptide.proce Human.genomic.DNA..c H3.histone..family.3A purinergic.receptor.P2Y major.histocompatibilit myosin.light.chain.kina colony.stimulating.facte cathepsin.O Homo.sapiens.cytochro jumonii mouse homol

jumonji..mouse..homol Human.leukocyte.antig Human.gene.for.natriur



Generation 2

Investigate viability of microorganisms in aerosolized form.

Compare genetic profile of multiple generations.

2+ microorganisms survive, what are their community dynamics?



Long-term evolution experiment replicating changing Venus conditions.



Generation 1

Generation 2



Further Thoughts - MUCH Further









JPL-Caltech/Spring et al. 2018/Oxford Nanotechnologies



The public is interested in the possibility of life on Venus.













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