

Phosphine in Venusian Clouds: chemistry or biochemistry?

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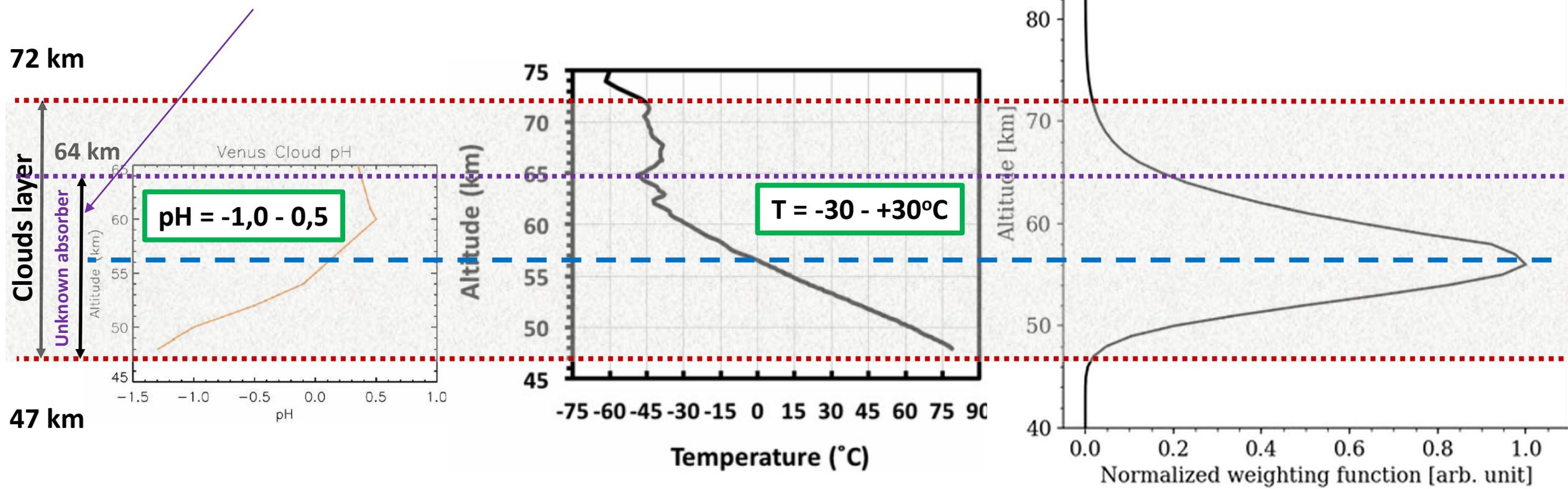


Phosphine gas in the cloud decks of Venus

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The altitude range and pH and temperature profiles in the cloud layer where phosphine absorption was detected

The spectral absorption by the unknown materials in the clouds of Venus



Grinspoon and Bullock. Monograph Series. 2007

Limaye et al. Astrobiology. 2018

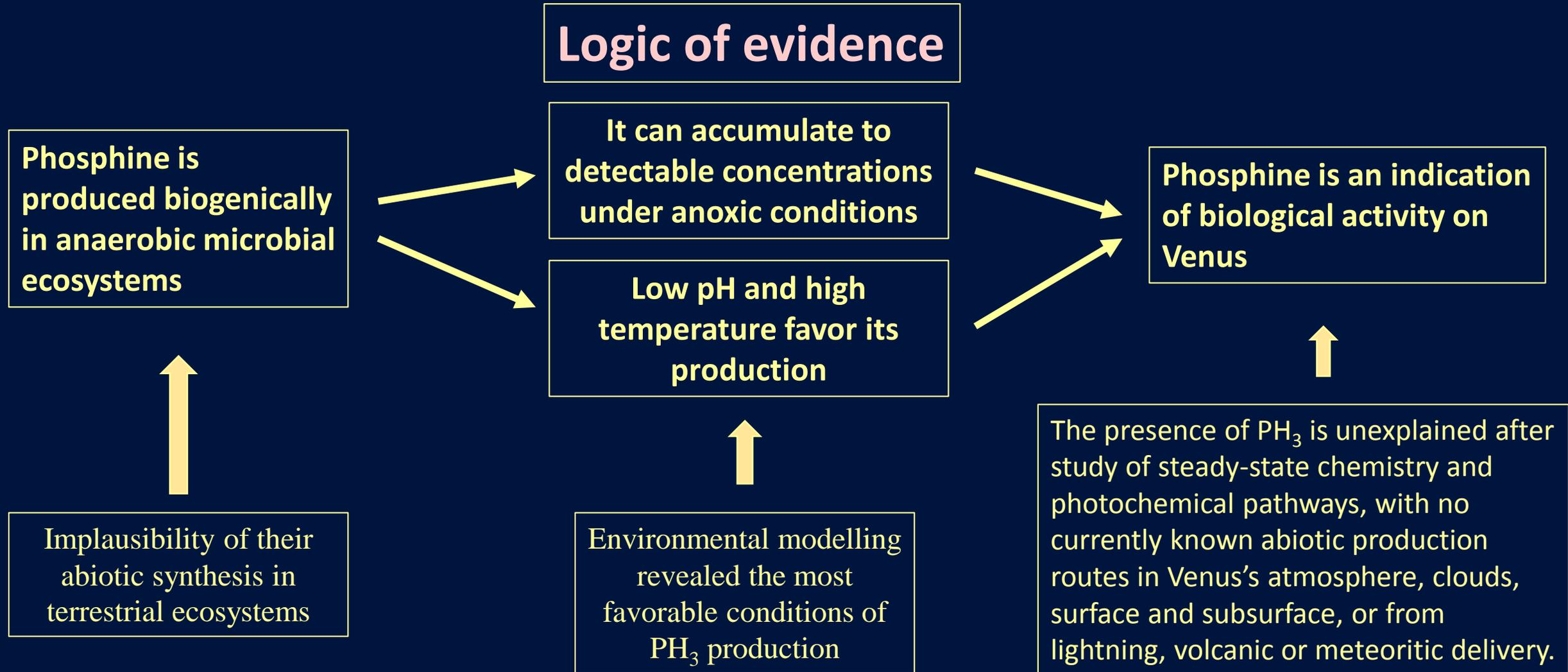
Greaves et al., 2020 Nature Astronomy

The concept

Phosphine is a promising biosignature gas

Bains W. et al. / Science of the Total Environment 658 (2019) 521–536

Sousa-Silva C. Et al. / Phosphine as a Biosignature Gas in Exoplanet Atmospheres. Astrobiology 2020



Terrestrial anoxic ecosystems where phosphine was detected

Rivers and lakes (Feng et al., 2008; Gassmann, 1994; Han et al., 2011b)

Landfills (Ding et al., 2005; Roels and Verstraete, 2004)

Wetlands and marshlands (Chen et al., 2017; Devai and Delaune, 1995; Eismann et al., 1997a, b; Han et al., 2000).

Faeces and flatus from many animals including

termites (Pech et al., 2011)

penguins (Zhu et al., 2014b, 2006)

cattle and pigs (Eismann et al., 1997a, b; Glindemann et al., 2005a)

fish (Gassmann and Glindemann, 1993)

and humans (Chughtai and Pridham, 1998)

Proof of biological origin

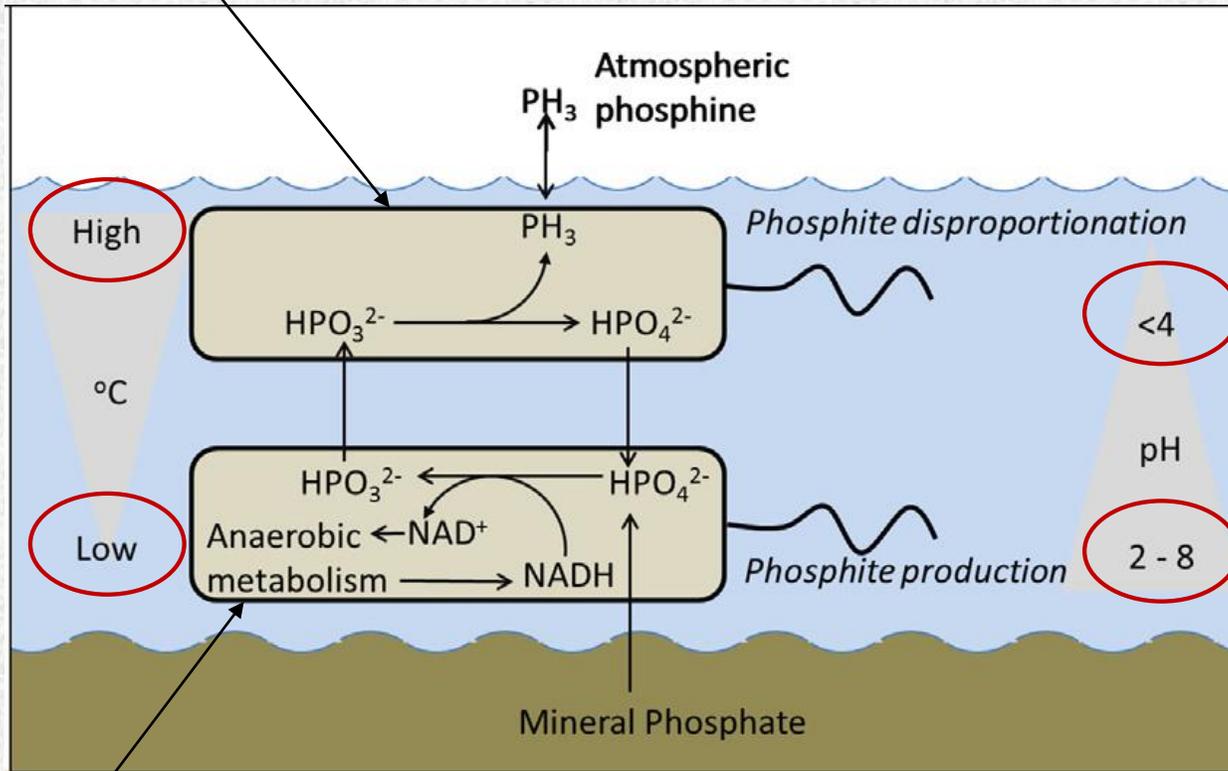
The synthetic pathways for most of life's natural products are not known, and yet their origin is widely accepted to be biological because of the **implausibility of their abiotic synthesis**, their **obligate association with life**, and their **chemical similarity to other biological products**.

The absence of a known enzymatic mechanism **is not evidence** for the absence of biological production.

Illustration of a hypothetical terrestrial phosphine-producing ecosystem

A single organism using hydrogen as a substrate cannot produce phosphine by reduction of phosphate as a source of energy

A warmer, upper, also anaerobic layer of organisms then disproportionate the phosphite to phosphate and phosphine, which is subsequently released into the atmosphere.

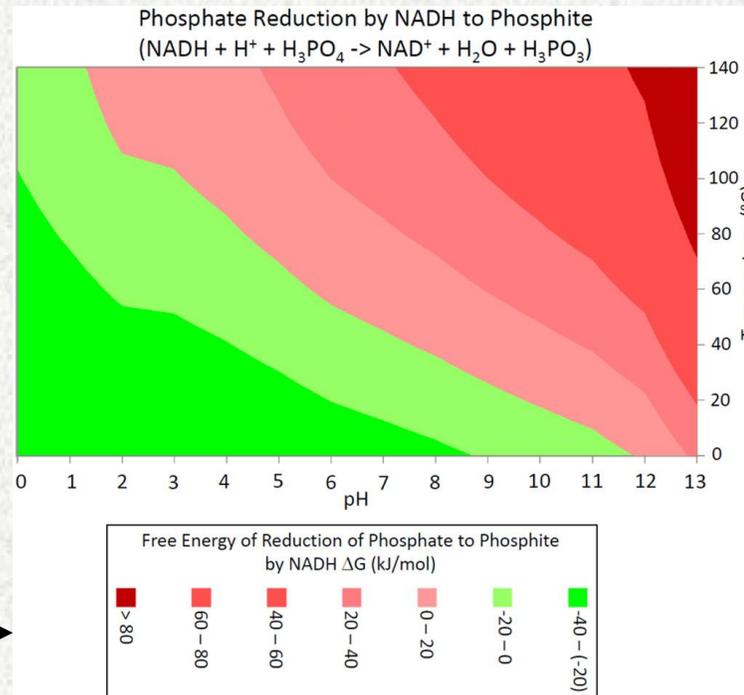
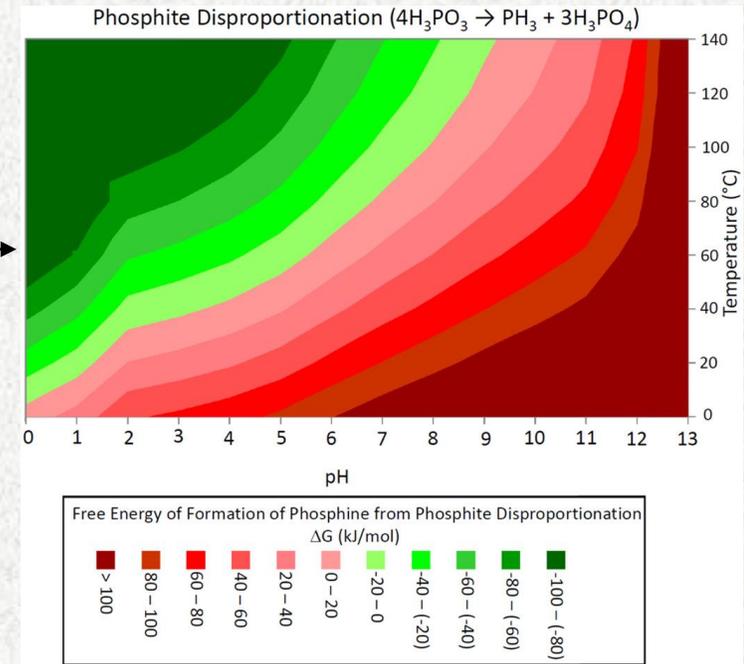


**pH = 0-4
T = 20-100°C**

**pH = 2-8
T = 0-40°C**

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A cool, acidic, anaerobic lower layer of organisms reduce phosphate to phosphite using NADH



PH₃ as a biomarker on Venus and other cosmic bodies

Phosphine is a promising biosignature gas, as it has no known abiotic false positives on terrestrial planets from any source that could generate the high fluxes required for detection



PH₃ can accumulate to detectable concentrations on habitable terrestrial planets with CO₂- and H₂-dominated atmospheres as a result of surface production



PH₃ can more readily accumulate on low-UV planets, for example, planets orbiting quiet M dwarfs or with a photochemically generated UV shield



Phosphine fulfills the first two criteria: PH₃ is only known to be associated with life and geochemical false positives for PH₃ generation are highly unlikely

Questions to be answered

Phosphine is produced biogenically in anaerobic microbial ecosystems

It can accumulate to detectable concentrations under anoxic conditions

Phosphine is an indication of biological activity on Venus

Low pH and high temperature favor its production



New studies of phosphine production in terrestrial ecosystems: field measurements, generating ecosystems, microbial agents

Biochemical pathways

Checking processes of phosphine production other than biological pathways