# Could we build an open air swimming pool on Mars?





## A trip to Mars?



Credit: NASA, ESA, and The Hubble Heritage Team (ST<u>ScI/AURA)</u>



Credit: NASA











## How about building an open-air swimming pool on Mars?

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# A swimming pool

needs water

## How about building an open-air swimming pool on Mars?

# Is or was there liquid

water on Mars?

# Comparing to the Earth, Mars is...



Credit: NASA

## Smaller



Credit: NASA

## Mars radius ~ 0,5 Earth's

Gravity: 38 % Earth's

#### Farther from the Sun



1,52 times farther fromthe Sun than Earth1 "martian year" = 687Earth days

Credit: NASA

### Similar



Earth

23°

1 "martian day" = 24 h 37 min

Axis tilt : similar to Earth

=> Mars has seasons!

Image credit: Calvin J. Hamilton.

Mars

25°

## **Different: topography**

Dichotomy North: lower altitudes, young surface South: higher altitudes, old surface Carte topographique de Mars



Credit photo: MOLA Team

PARTY IN COMPARING MADE

South

North

#### **Different: atmosphere**

eesa

ARGON 1.9% OXYGEN 20.9% NITROGEN NITROGEN 1.9% 78.1% CARBON DIOXIDE 96% TRACE GASES, INCLUDING: TRACE GASES, INCLUDING: ARGON (0.93%) CARBON DIOXIDE ACETYLENE HELIUM CARBON MONOXIDE HYDROGEN KRYPTON KRYPTON METHANE METHANE NEON NEON NITROGEN OXIDE NITROUS OXIDE OXYGEN OZONE OZONE SULPHUR DIOXIDE WATER VAPOUR MARS EARTH WATER VAPOUR XENON XENON Atmospheric composition by volume | Planets not to scale | Atmosphere of Mars is less than 1% of Earth's | Trace pases listed alphabetically

→ COMPARING THE ATMOSPHERES OF MARS AND EARTH

Thinner atmosphere:

1 % Earth's in volume

Low pressure:

6 mbar

0,6 % Earth's (1 bar)

www.esa.int

European Space Agency

Credit: ESA

#### How warm?



Mean temperature: - 58 °C In summer, temperature can vary from -120 °C to 20 °C in one day!

Credit: NASA, ESA, and The Hubble Heritage Team (STScI/AURA)

### Mars is a cold desert!



Martian Landscape Credits: NASA/JPL-Caltech/MSSS



Death Valley Landscape Credits: NASA/JPL

# Water on Mars?



Credit & Copyright: Ellen Roper (GCC)

### Water ice





Credit ESA/DLR/Freie Universitat Berlin (G. Neukum)



Image credit: NASA/JPL/Malin Space Science Systems



Image credit: NASA/JPL

#### Water vapor



Credit: Dmitry Shaposhnikov et al. (2018)/Journal of Geophysical Research: Planets

## Liquid water on Mars?



## Liquid water: recurring slope lineae?



Image Credit: NASA/JPL-Caltech/Univ. of Arizona

#### Liquid water: under the south polar water ice?



Image Credit: Context map: NASA/Viking; THEMIS background: NASA/JPL-Caltech/Arizona State University; MARSIS data: ESA/NASA/JPL/ASI/Univ. Rome; R. Orosei et al 2018

## Liquid water on Mars?



Stable liquid water could not exist on the surface of Mars!

## Liquid water on Mars?



## Liquid water on Mars in the past

Gullies







#### Liquid water on Mars in the past

#### Martian "blueberries" (hematite, iron oxyde)



Credits : MER/Opportunity

#### **Clays and sulfates**



Credits : Mars Express/OMEGA

# Traveling back in time...



#### Liquid water on Mars surface: when?



#### Liquid water on Mars surface: when?



#### What was the climate of Early Mars? (3 hypothesis)

- Warm and wet Mars
- Cold and wet Mars
- Cold and dry with episodic

warming



Artist view of an Ancient Mars covered by water (Credit: Itiz, shared under a CC BY SA 3.0 license)



#### How thicker was the atmosphere on Early Mars (3.9 Gyr ago)?

- 0.5 to 2 bar (Kite et al., 2013)
- 0.25 to 1.9 bar (Pham and Karatekin, 2016)
- Higher than 0.5 bar (Kurokawa et al., 2018)



#### How thicker was the atmosphere on Early Mars (3.9 Gyr ago)?





CO<sub>2</sub> ice condensation and sublimation

#### How to remove atmosphere





C Addison-Wesley Longman



#### How to remove atmosphere





C Addison-Wesley Longman



#### How to remove atmosphere





#### How to remove atmosphere



CO<sub>2</sub> sequestration in carbonates reservoirs

> No big carbonate reservoir discovered (Bibring et al., 2005)

C Addison-Wesley Longman



#### How to remove atmosphere



C Addison-Wesley Longman





## Water melting point?



Salts solution could lower water fusion temperature

### Salt solutions

Usual example of Martian solutions	Melting point (°C)
Sulfate salts (maximum)	- 10
NaCl (eutectic) <sup>1</sup>	- 21
$Na_2SO_4 + NaCI + H_2O$	-23
Perchlorate (NaClO <sub>4</sub> ) (eutectic) <sup>1</sup>	- 33
Up to 3000 ppm salt concentration (Antarctic Dry Valles)	- 56
Perchlorate ( $Mg(ClO_4)_2$ )	- 69
$H_2SO_4 + H_2O$	- 72
Perchlorate (Ca(ClO <sub>4</sub> ) <sub>2</sub> )	- 75

<sup>1</sup>Eutectic refers to the point of the diagram phase for which a given melange is at its minimal temperature in liquid phase.

#### How to warm Early Mars?

#### Faint young Sun problem

The Sun was 30 % fainter than today



#### How to warm Early Mars?

Greenhouse warming: CO<sub>2</sub> is not enough : T < -48 °C (Wordsworth et al., 2011, Wordsworth 2016)



Credit: NASA, artist Kees Veenenbos

#### Other possible sources of (episodic) warming

- Other greenhouse gases ( $H_2$ ,  $SO_2$ ,  $CH_4$ ...)
- Warming by impacts (Segura et al., 2008, 2012)
- Volcanic outgassing (SO<sub>2</sub>, H<sub>2</sub> S) (Johnson et al., 2008, Halevy & Head, 2014)











## So, how about building an open-air swimming pool on Mars?

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On present Mars: not possible

## So, how about building an open-air swimming pool on Mars?

On Early Mars: Water + perchlorates swimming pool if T > - 65 °C Good...

## Indoor swimming pool are better!

## Thank you for your attention!

