METHANE ON MARS STUDY PROGRAM

Vision & Goals

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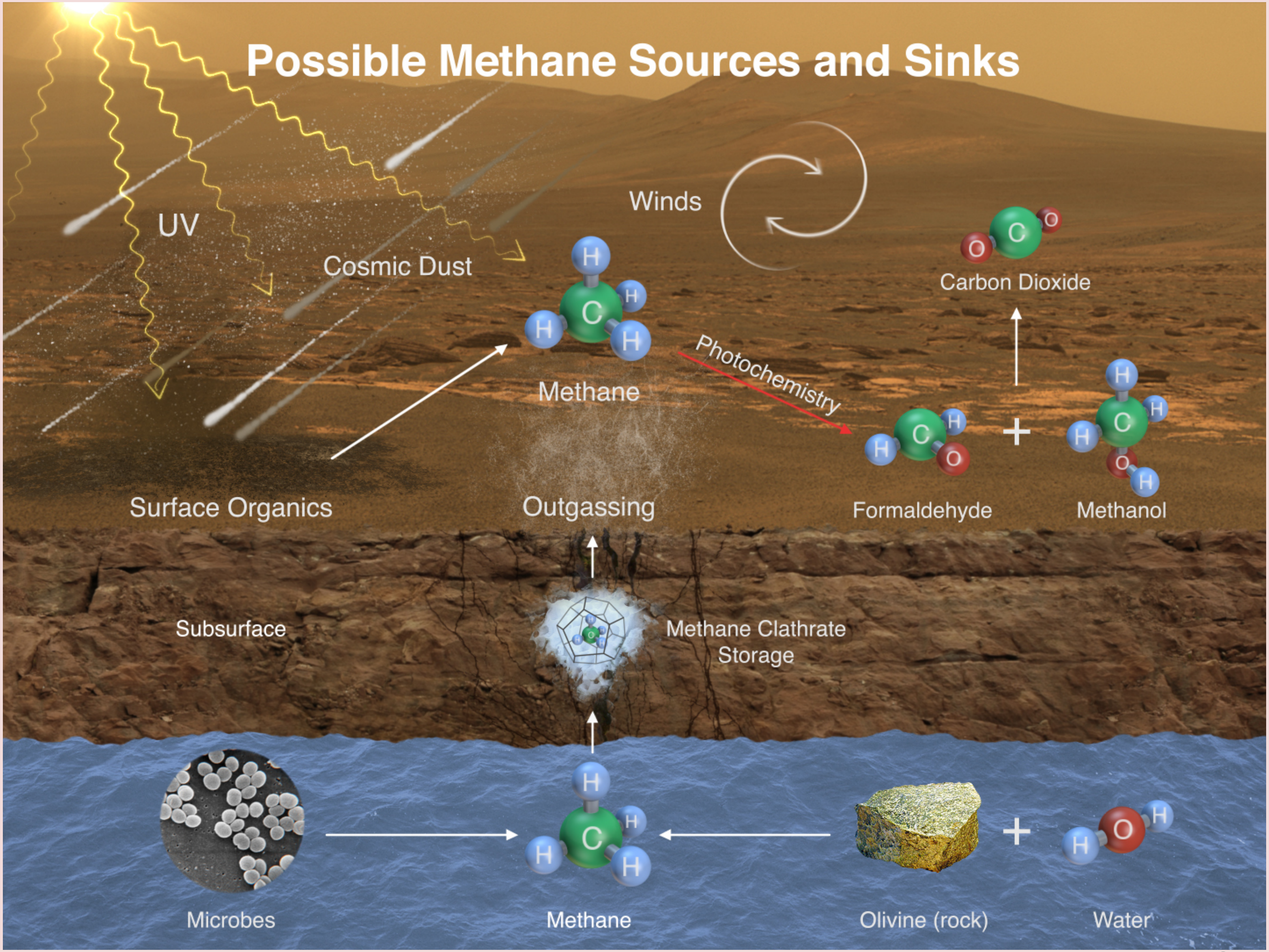
KISS Workshop 12-7-2015



Courtesy: Atreya

MOTIVATION

Ground-based and **Mars Express** observations of methane on Mars have been **extremely interesting but tentative.**

The **MSL** detection and the observed temporal patterns now **confront us with a firmness that demands answers.**

MOTIVATION

Methane can have **many different origins.**

Determining the origin of these signals **provides considerable insight** into the present and past of the planet.

We may learn about the **evolution** of a non-living planet, or we may be convinced of past—or even present—**signatures** of methane-connected **life forms**.

MOTIVATION

Once we have **determined the questions** that must be answered to do this, the technology needed to accomplish it can be defined.

Until then, we are not equipped to define the technological direction(s) needed.

WORKSHOP VISION

1. Define the scientific questions. All of us have several key questions we can put forward, and they come from a wide variety of backgrounds. Discussion of these is the top priority of the next few days.

2. Identifying the origin of methane. How can the methane signal be used to distinguish between geochemical, geophysical, atmospheric chemistry, and/or biological origins?

WORKSHOP VISION

3. Use temporal patterns as an additional dimension of information content. They present both challenges and opportunities to further understand Martian processes.

4. Begin a new era. If we define priority science questions, we will have succeeded. If we move beyond to specifying methods for answering the really hard questions, it could be the beginning of a program that would have great importance in terms of space science—technical approaches to distinguish past and present biology from abiological processes.

WORKSHOP GOALS

1. Identify **potential methane sources** meriting investigation

2. Define **prioritized scientific questions** for distinguishing potential methane sources

3. Identify types of **necessary measurements** for answering the questions

4. Define plans for the **inter-workshop** and **workshop-2** plans

OPEN DISCUSSIONS

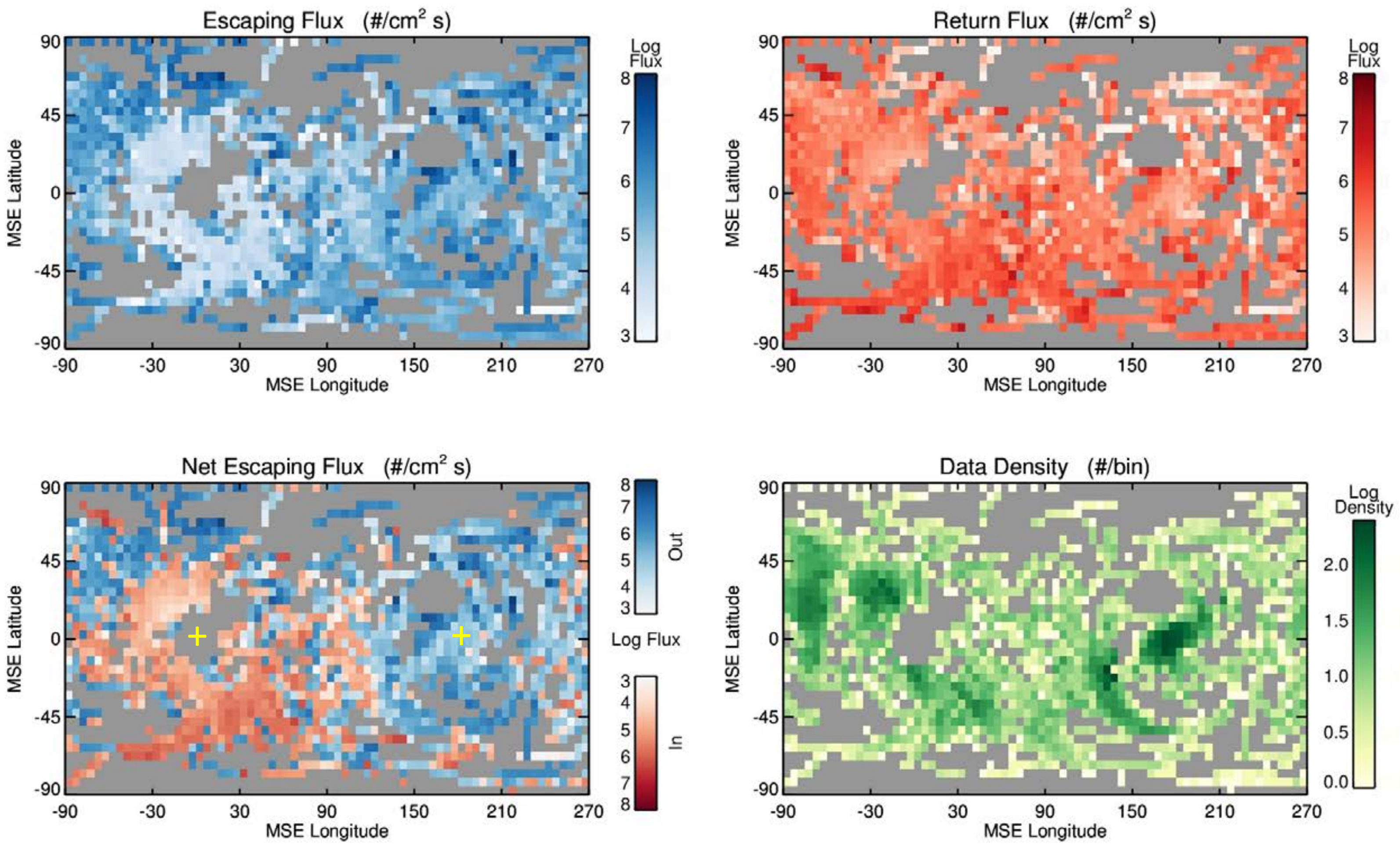
Everyone owns the workshop and its vision.

Everyone plays a role and **shares the responsibility** for the workshop's success, so please **participate boldly.**

Spirited debate, controversy, and **uninhibited exchange of ideas** are all good for the workshop!

Total Escaping Flux

Courtesy Jakosky



- Ion escape rate ~ 3 x 10^{24} s^{-1}, or ~100 g/s
- Not expected to be constant through time

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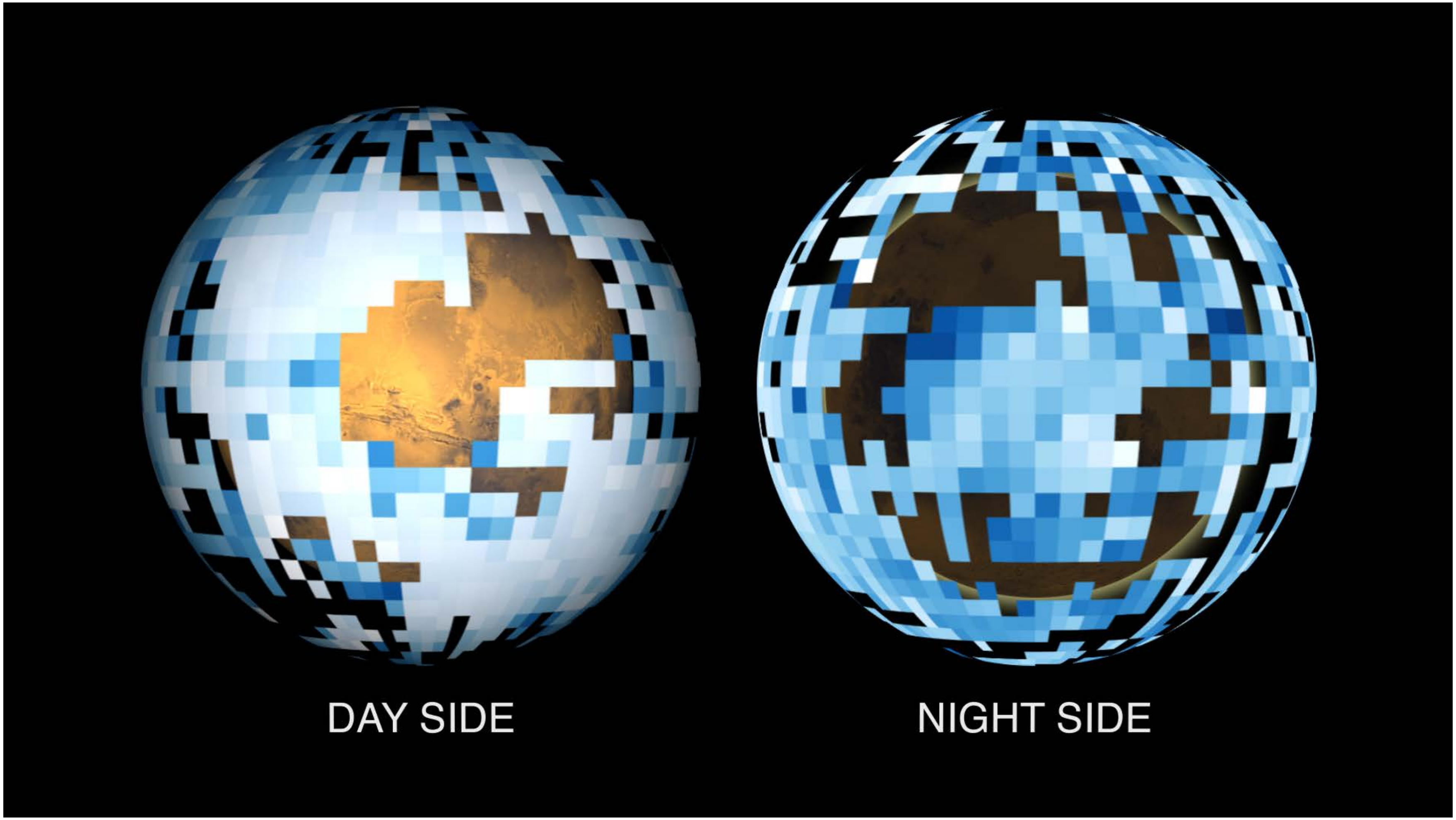
Courtesy Jakosky



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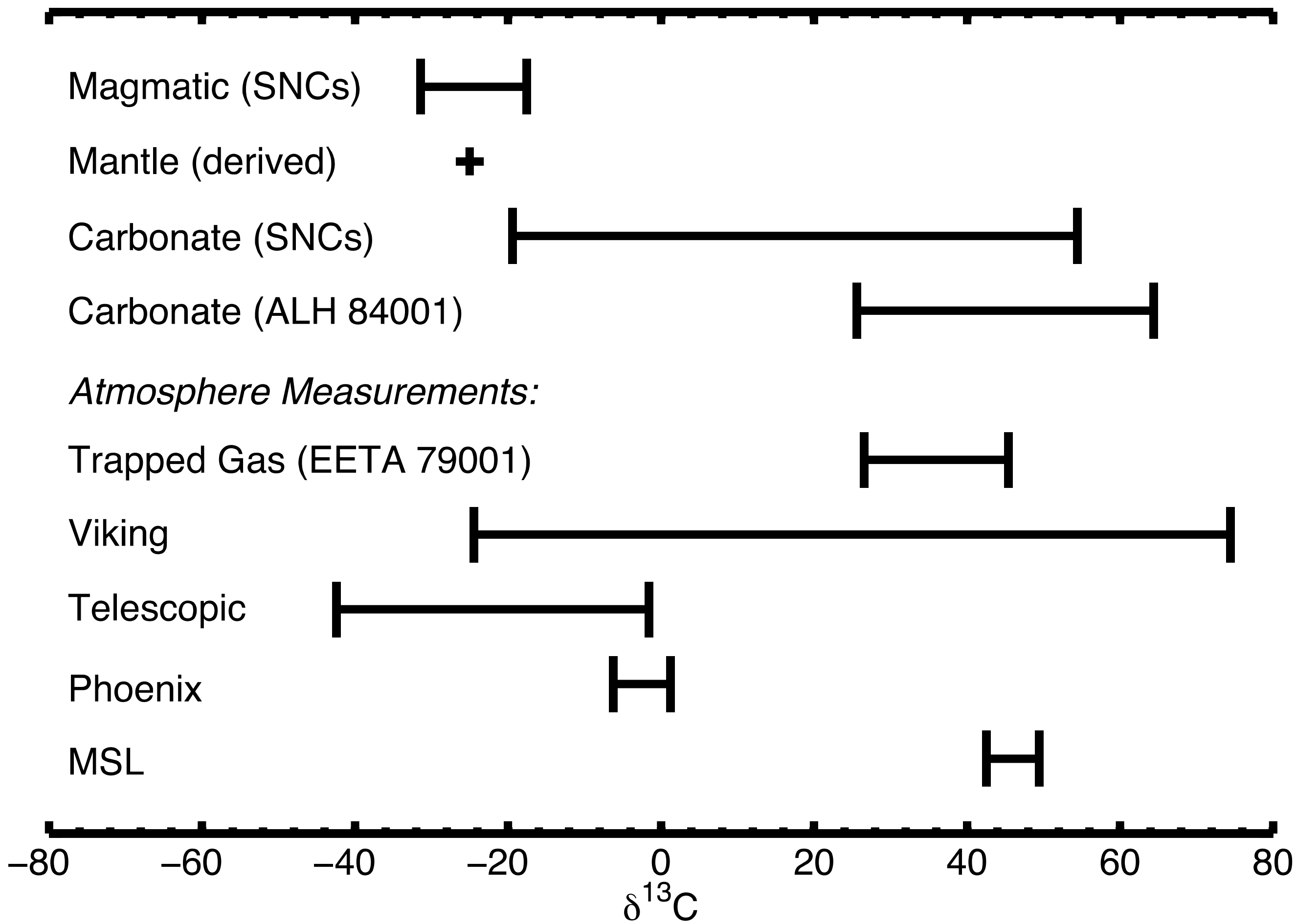
Substantial enrichment in heavy isotopes is evident in multiple atmospheric species, including argon, carbon and oxygen in CO2, and hydrogen and oxygen in water vapor (64–66). These results point to an initial atmospheric mass and water inventory in Mars's secondary atmosphere that were a few to many times greater than their present-day values.

Grotzinger et al. 2015

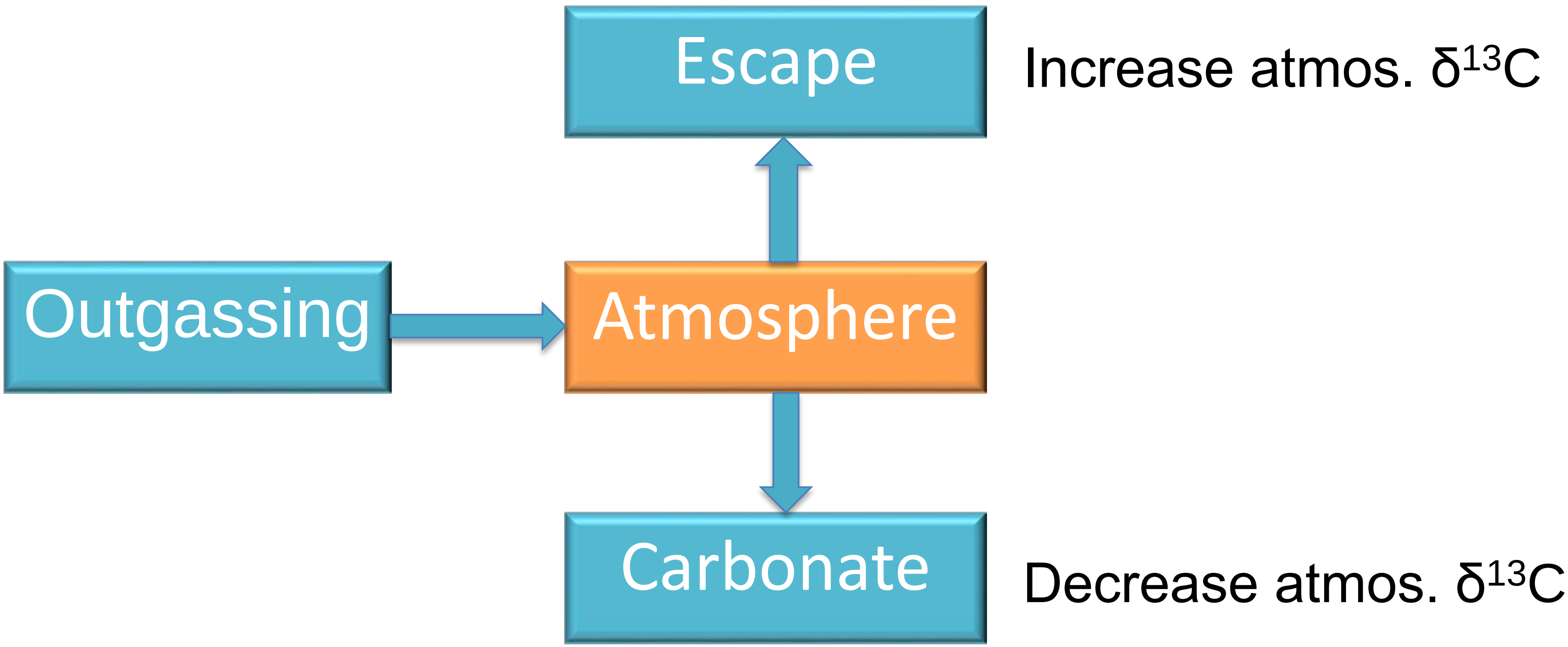
Evidence of Profound Evolution of a Planetary Atmosphere



$$\delta^{13}C \equiv \frac{{}^{13}C/{}^{12}C - ({}^{13}C/{}^{12}C)_{standard}}{({}^{13}C/{}^{12}C)_{standard}} \times 1000$$

Hu et al. 2015

Constraining the evolution of Mars



Problem:

How exactly does escape enrich the atmosphere?

A Moderately Dense Early Atmosphere

- An upper limit of 0.9 bar can be derived from when carbonate formed in the subsurface

- Or 1.7 bar when carbonate in surface lakes

The atmosphere does not collapse, allowing transient melting, runoff, and low-temperature hydrological cycles

Forget et al. 2013; Kite et al. 2014; Hu et al. 2015

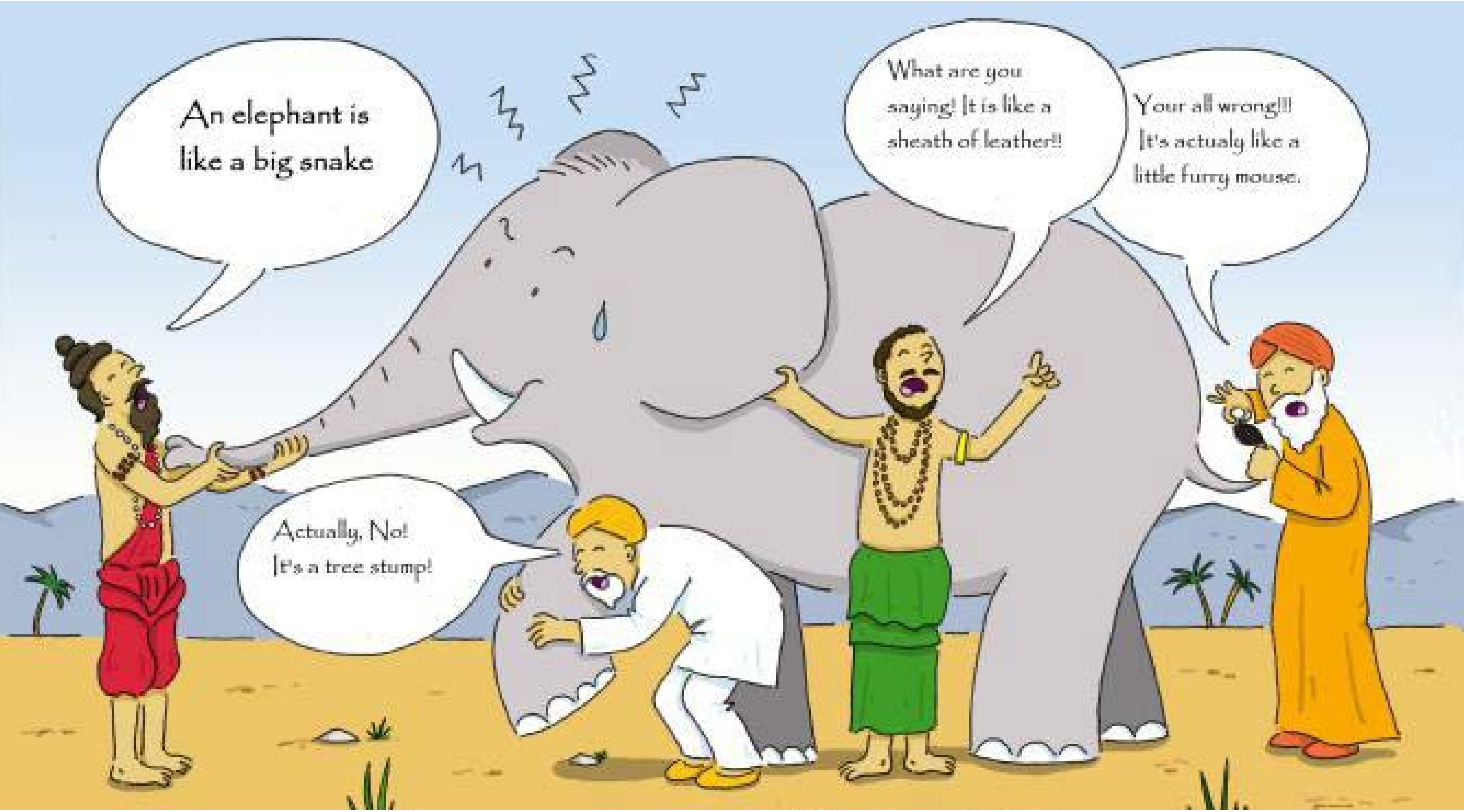
Not Only Carbon …

Isotopic Ratio	Mars Value	Relative to
$\delta^{13}C$ in CO_2	46 per mil	VPDB
δD in H_2O	5880 per mil	Earth Ocean (VSMOW)
$\delta^{18}O$ in CO_2	48 per mil	Earth Ocean (VSMOW)
$\delta^{15}N$ in N_2	572 per mil	Earth Atmosphere
$\delta^{38}Ar$	310 per mil	Sun

Mahaffy et al. 2013; Webster et al. 2013; Wong et al. 2013; Atreya et al. 2013

This is supported by deuterium/hydrogen isotope ratios from ancient clays in a Gale lake deposit, which indicate that a global-equivalent layer of water of 100 to 150m in thickness was present at the time of sediment accumulation

- Grotzinger et al. 2015
- Villanueva et al. 2015


An elephant is like a big snake
Actually, No! It's a tree stump!
What are you saying! It is like a sheath of leather!!
Your all wrong!!! It's actualy like a little furry mouse.