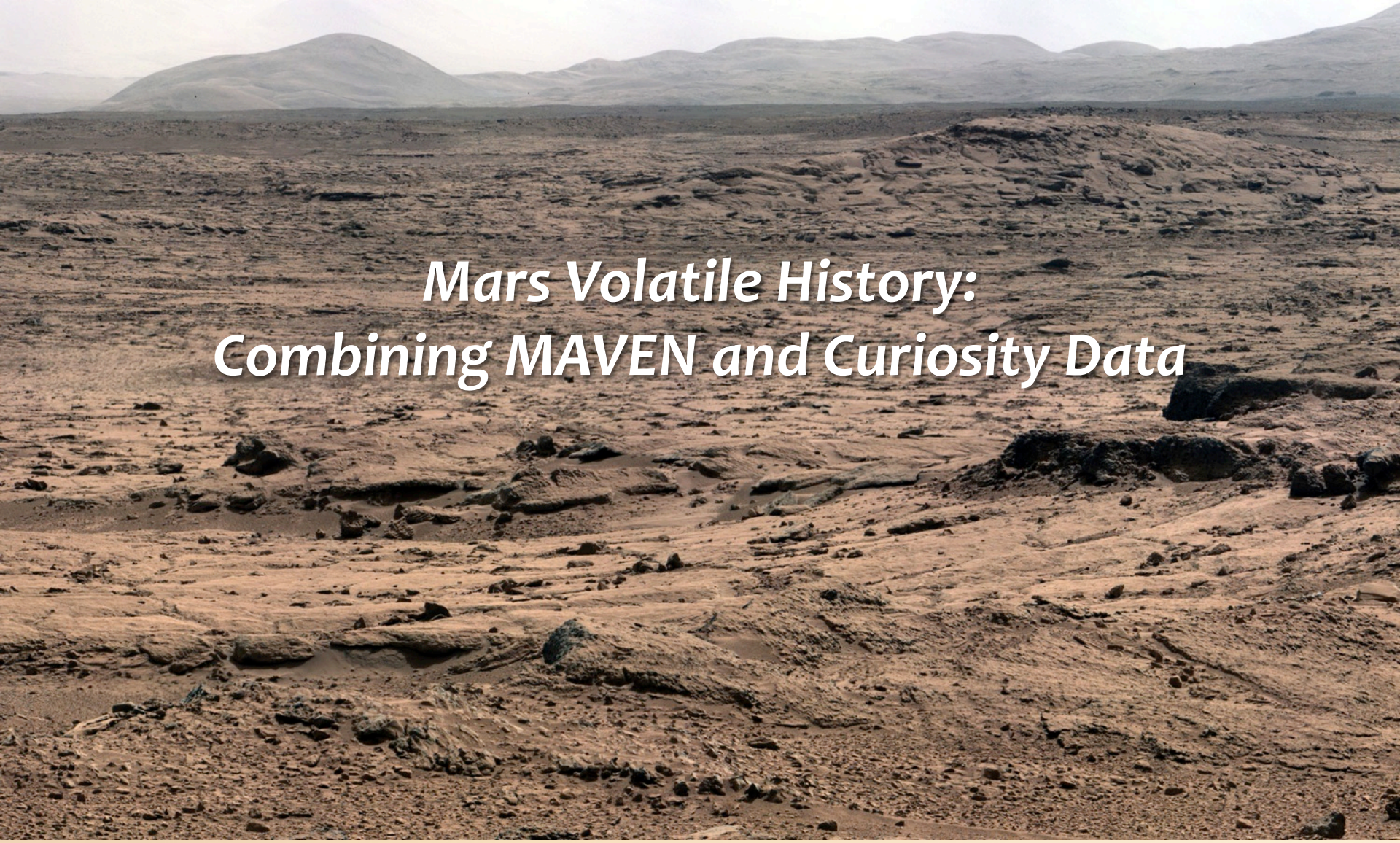


Mars Volatile History: Combining MAVEN and Curiosity Data

MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LM • JPL

Mehdi Benna
NASA GSFC/UMBC

Mars Science Laboratory

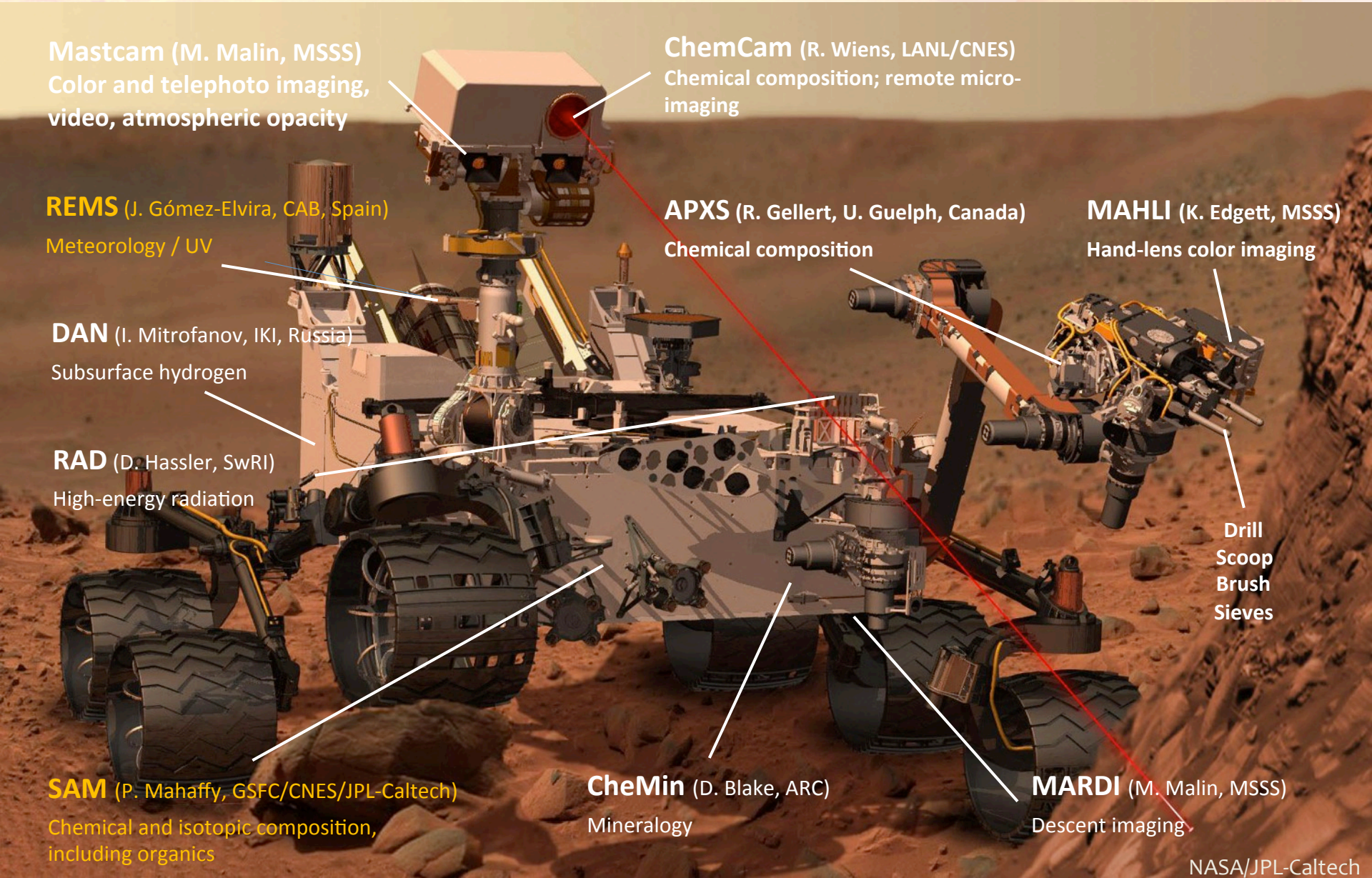
Mission Objectives

Curiosity's primary scientific goal is to explore and quantitatively assess a local region on Mars' surface as a potential habitat for life, past or present

- **Assessing the past and present biological potential of Mars**
  - Inventory of the organic and inorganic compounds and their processes of preservation
- **Characterizing surface geology and geochemistry**
  - Chemical, mineralogical and isotopic composition of Martian surface and subsurface + geological processes
- **Investigating planetary processes that influence habitability**
  - Understand long-term atmospheric evolution processes (4 G-yr).
  - Determine the state, distribution and cycle of water and CO2
- **Prepare sample return and manned missions to Mars**
  - Capability of landing of a considerable size/mass rover
  - Capability of landing in a 20 km wide ellipse
  - Radiation exposition measures

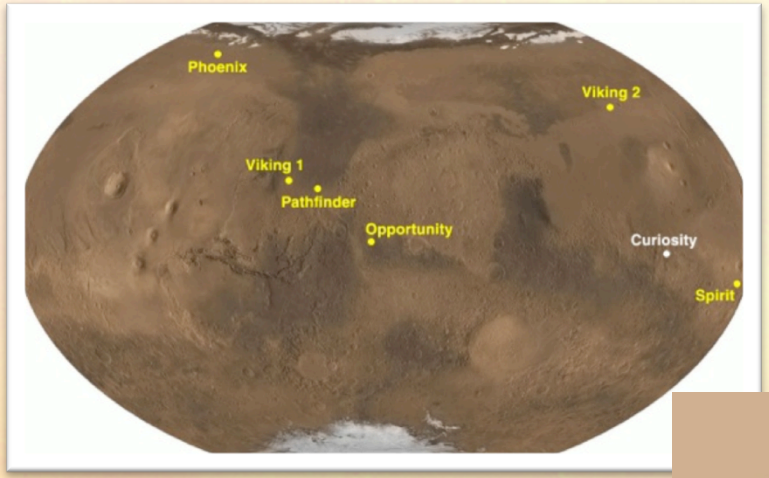

NASA/JPL-Caltech

Science Payload

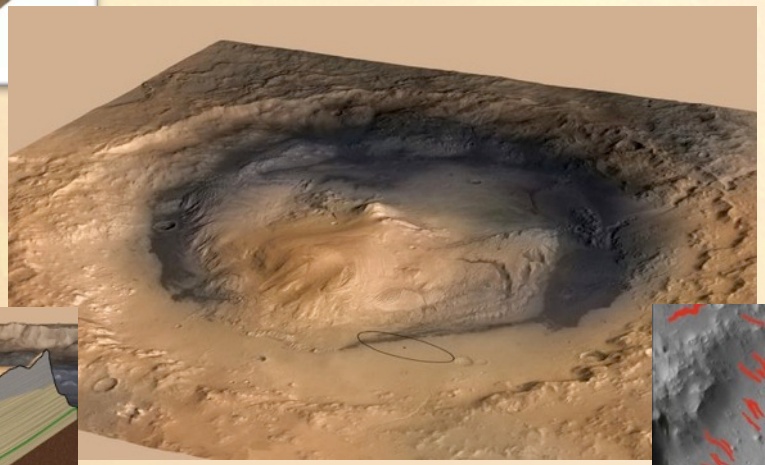


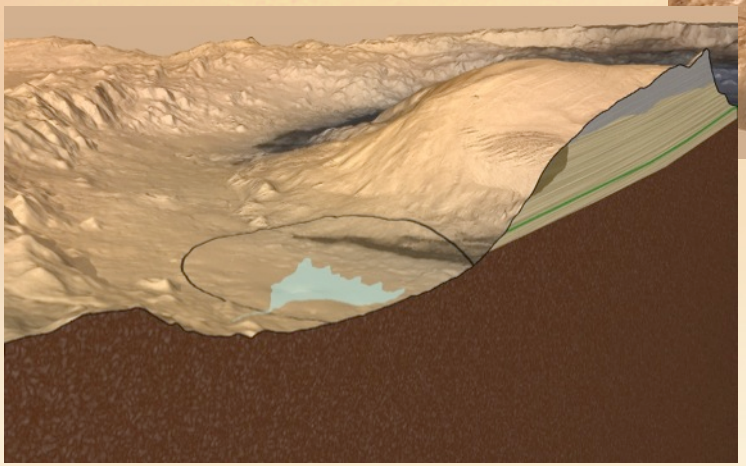
NASA/JPL-Caltech

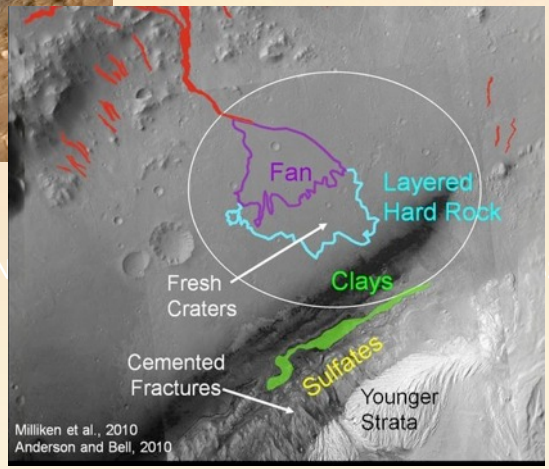
Landing Site: Gale Crater



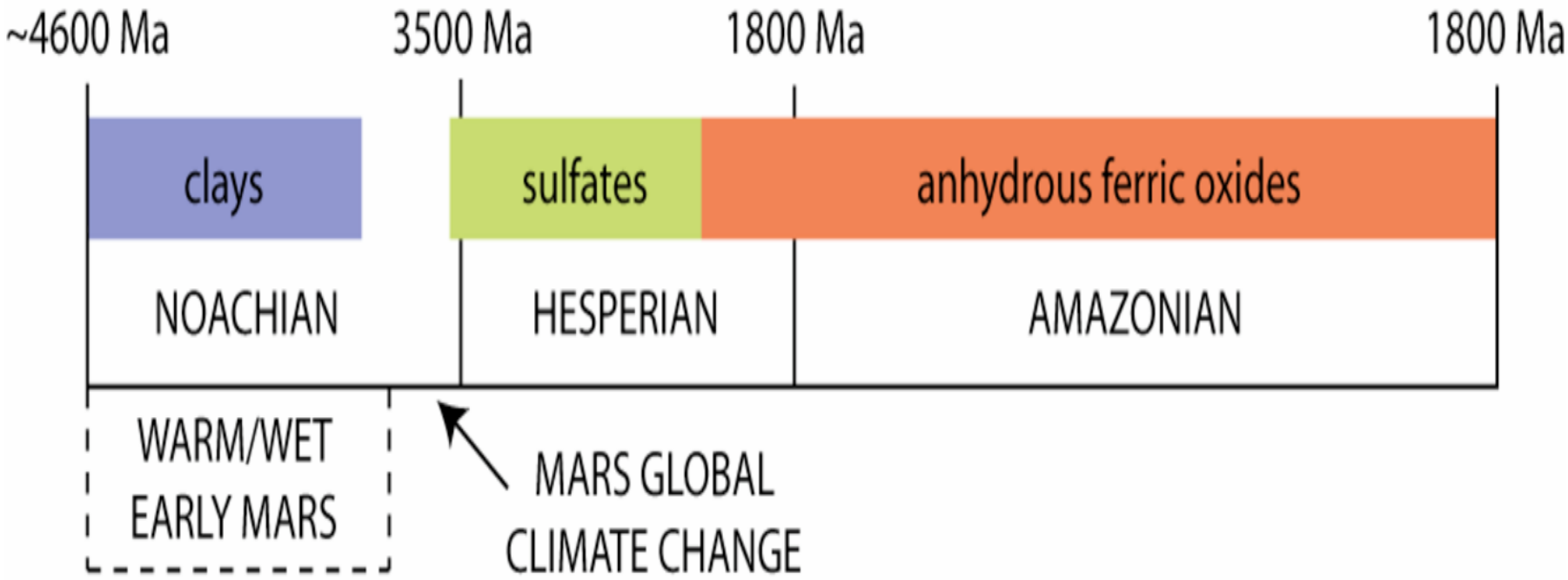
150-km Gale Crater contains a 5-km high mound of stratified rock. Strata in the lower section of the mound vary in mineralogy and texture, suggesting that they may have recorded environmental changes over time. Curiosity is investigating this record for clues about habitability, and the ability of Mars to preserve evidence about habitability or life.







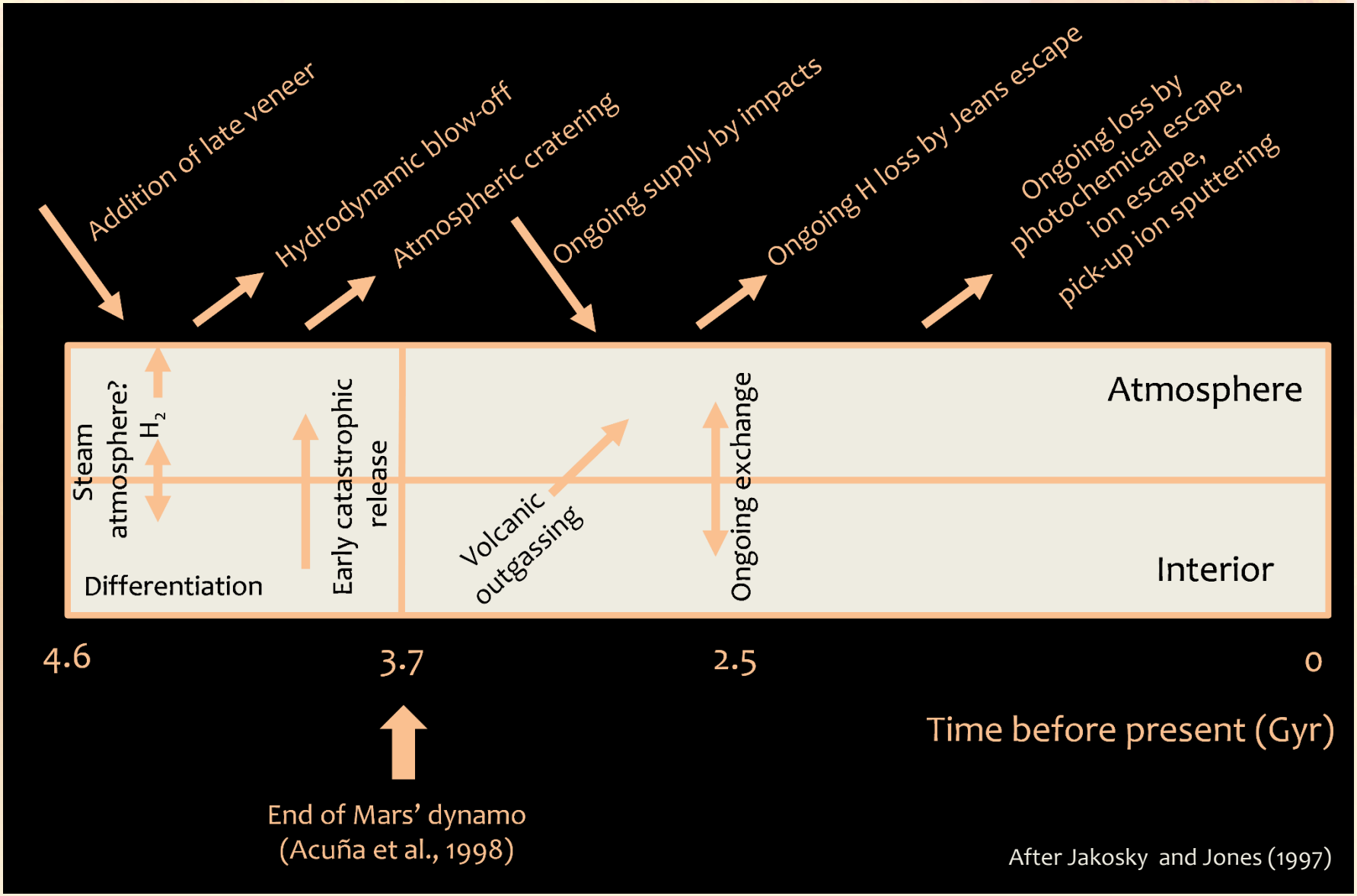
Why Gale Crater ?



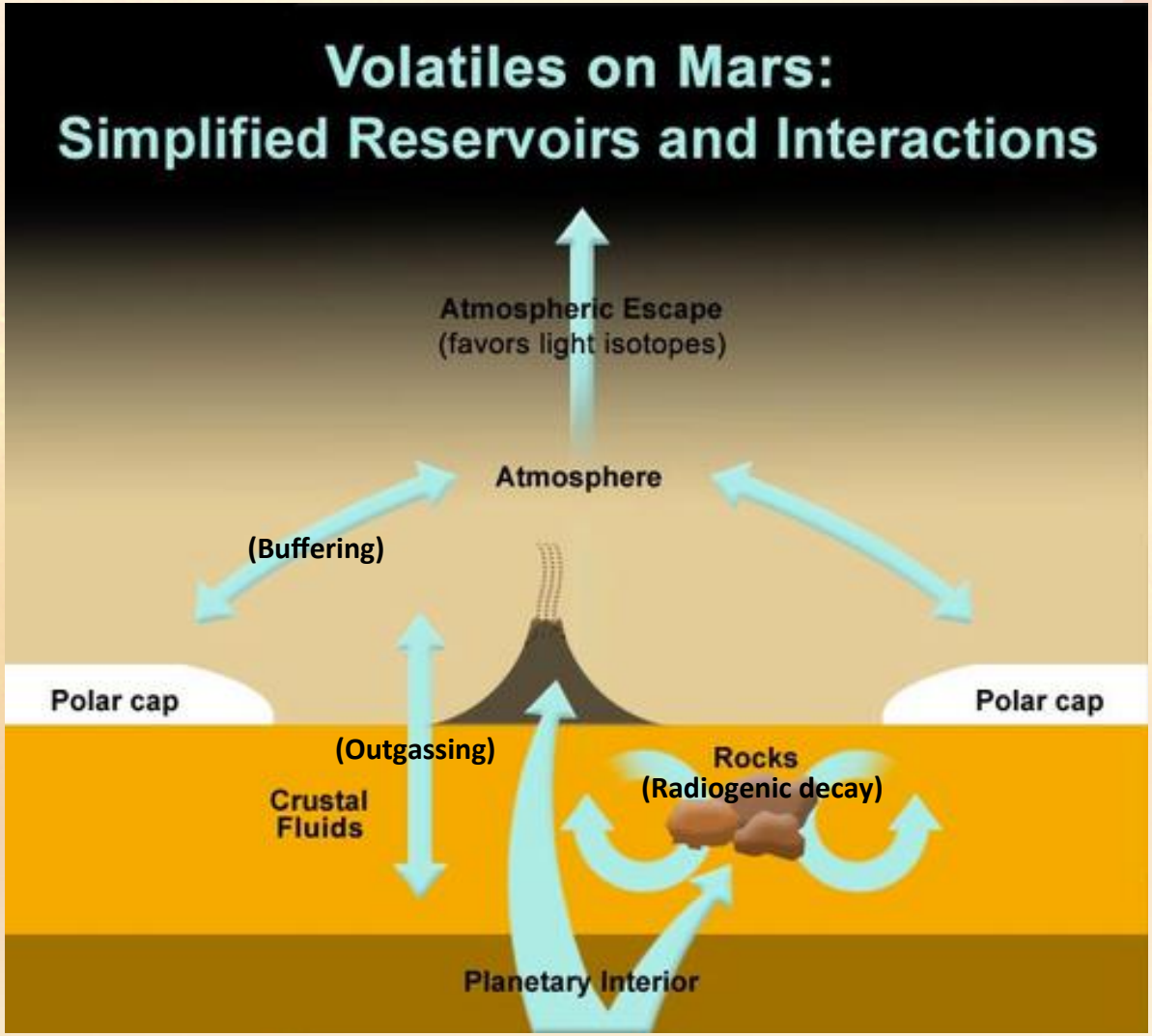
Bibring et al. (2006)

Stratigraphic change from clay-dominated to sulfate-dominated environments suggests that Gale Crater strata might record a critical transition in the history of the martian surface

Chronology of major events changing the Martian atmosphere

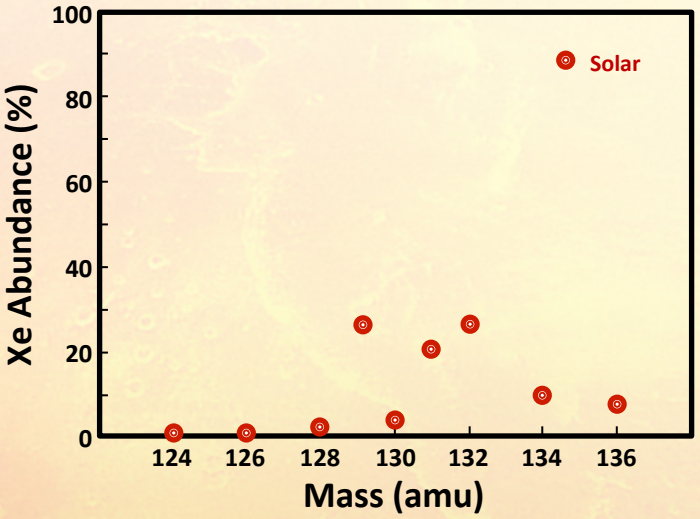


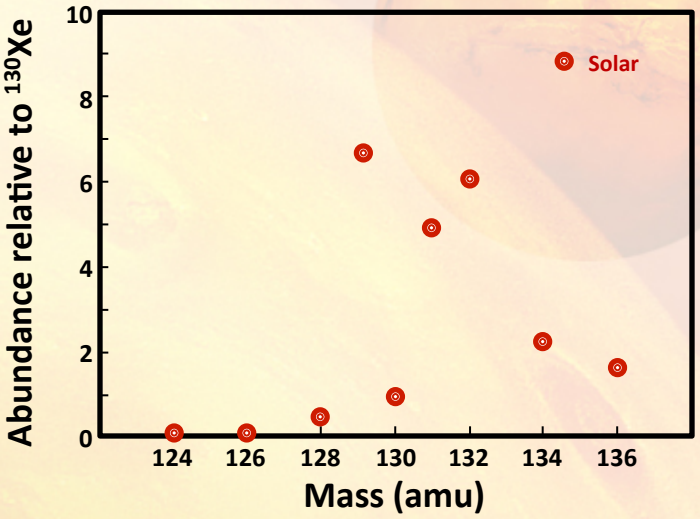
Isotopic composition = atmospheric fingerprints



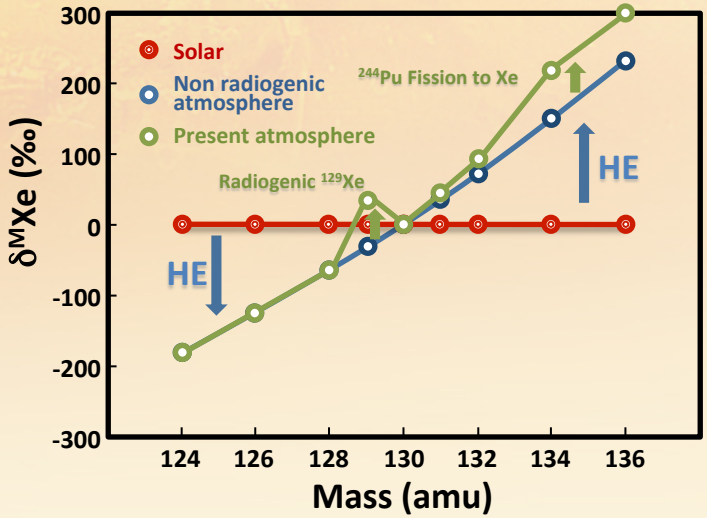
Most processes responsible for the evolution of the atmosphere produce isotopic fractionation

Earth's atmopsphere as an example





$$\delta MXe = 1000 \times (MXe/130Xe/MXesolar/130Xesolar - 1)$$

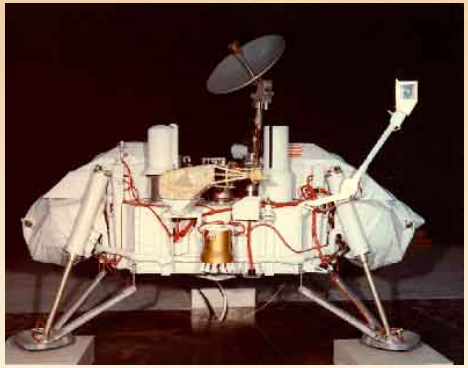


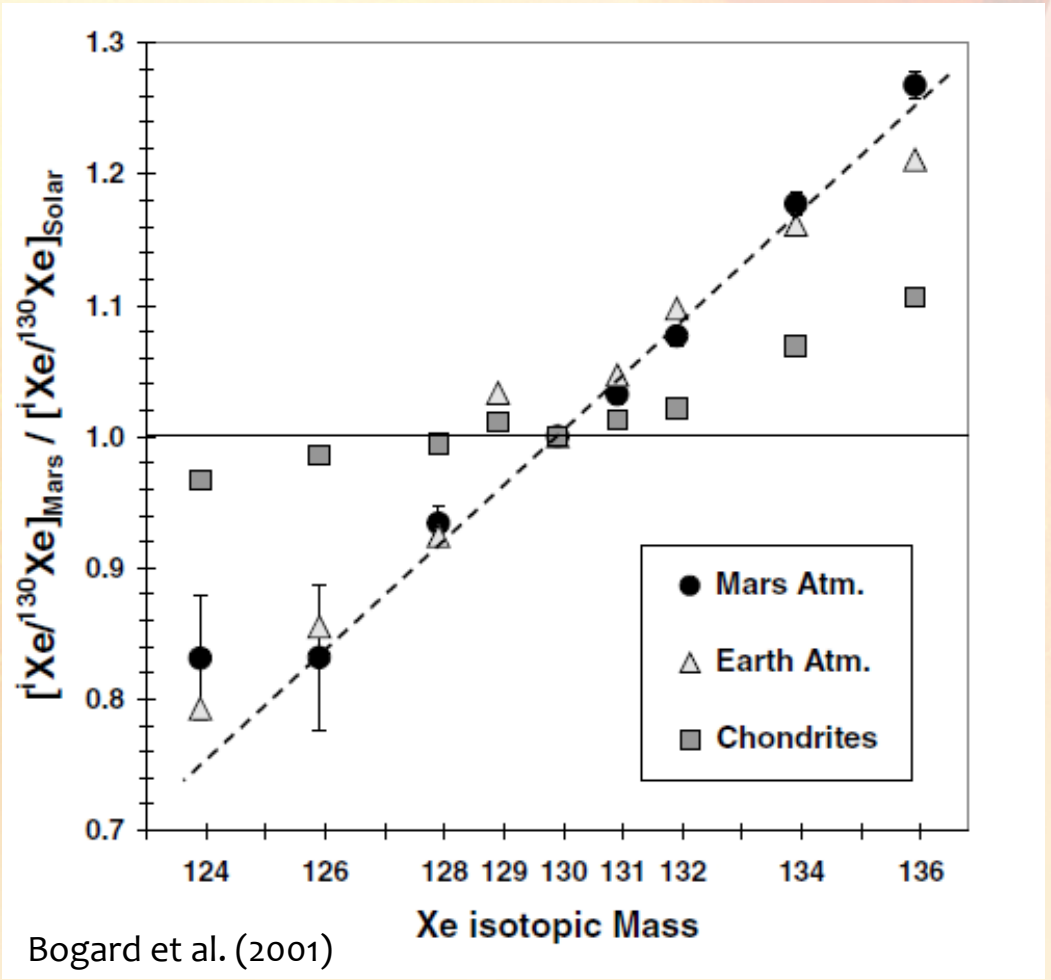
Martian atmosphere isotopic fractionation

Analyses of trapped gas in SNC meteorites show that the Martian atmosphere is also enriched in heavy isotopes.

Martian meteorite EETA79001

This results is in agreement with the less accurate isotopic measurements of the Viking Landers.



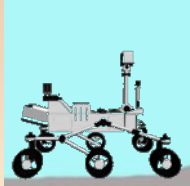


Bogard et al. (2001)

Constraining the climate history of Mars

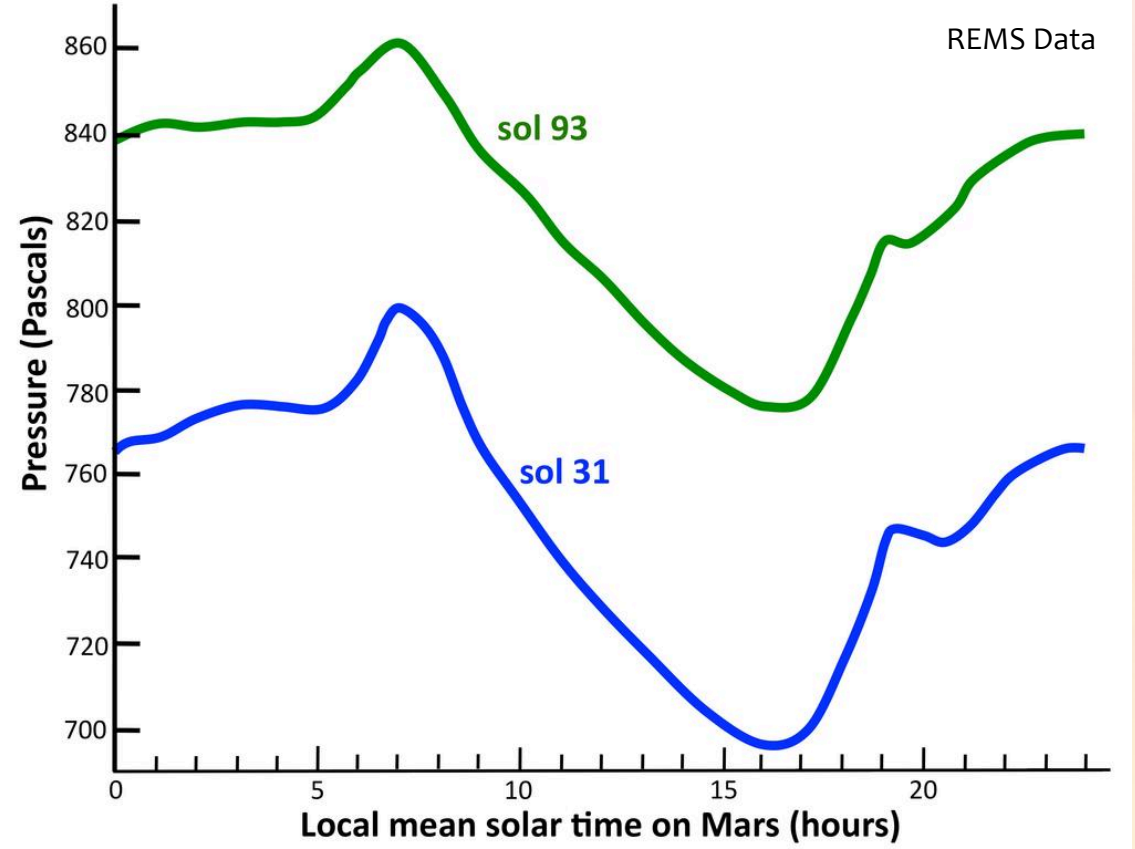
MSL - Part I:

- Current state of the atmosphere
- Current atmospheric exchange with surface reservoirs
- Ancient atmospheric records in rocks



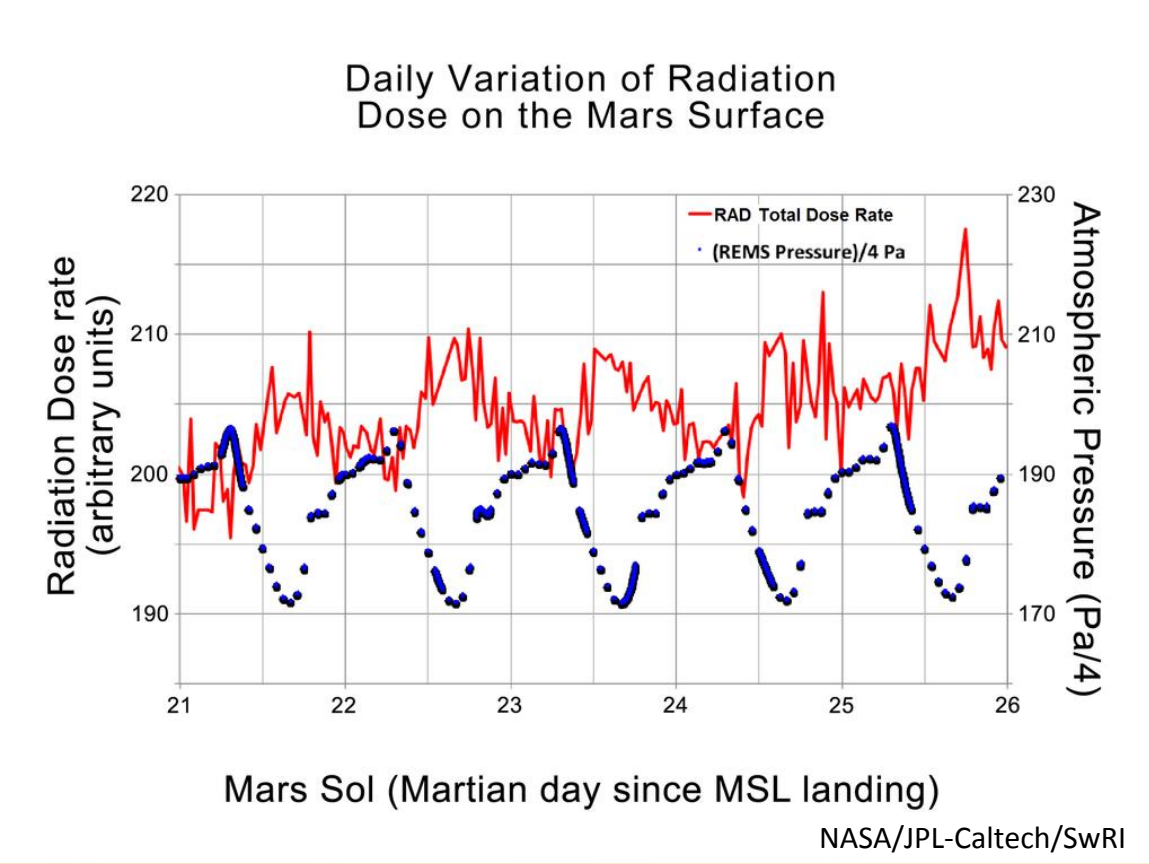
Diurnal and seasonal atmospheric pressure variation

- Each day the pressure varies by over 10% (compared to one tenth of 1% for earth)
- Solar heating of the ground drives a pressure "tidal wave" that sweeps across the planet each day
- Overall, the pressure is increasing as carbon dioxide sublimates from the southern seasonal polar cap



Atmospheric Shielding

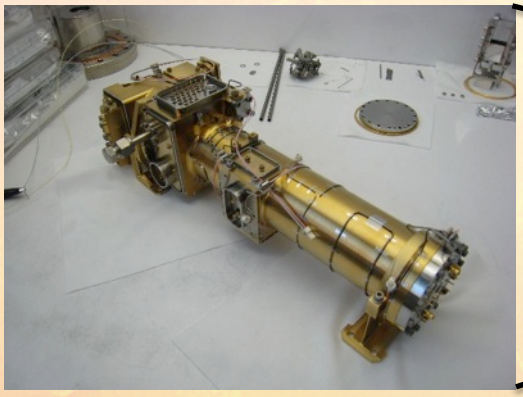
- RAD observed galactic cosmic rays and five solar energetic particle events traveling from the Sun to Mars
- The atmosphere of Mars partially shields the surface from radiation. When the atmosphere is thicker (higher REMS pressure), RAD measures less radiation



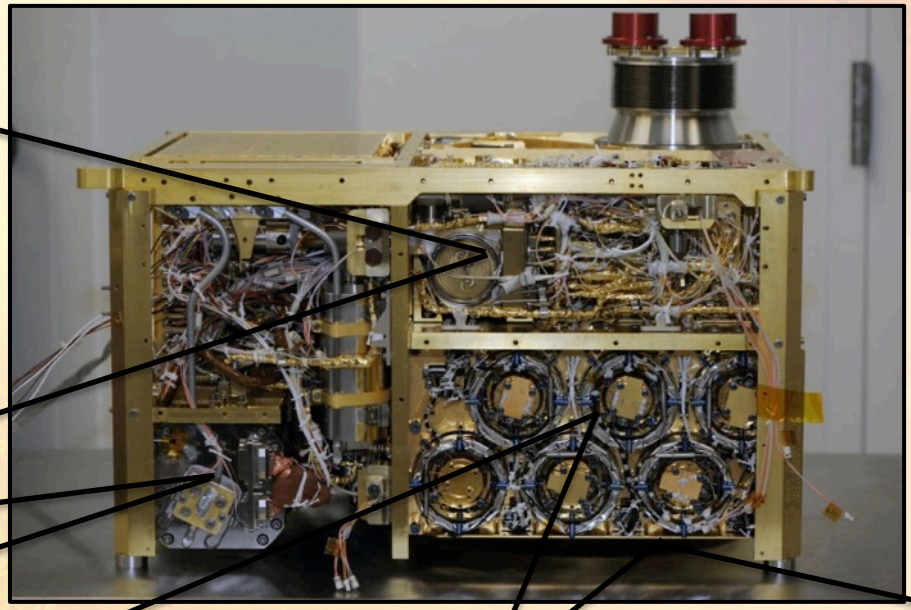
NASA/JPL-Caltech/SwRI

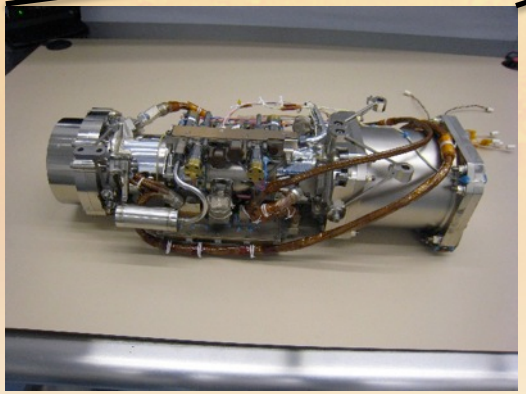
Sample Analysis at Mars (SAM) Suite

SAM analyzes atmospheric gas or vapors extracted from solids using:

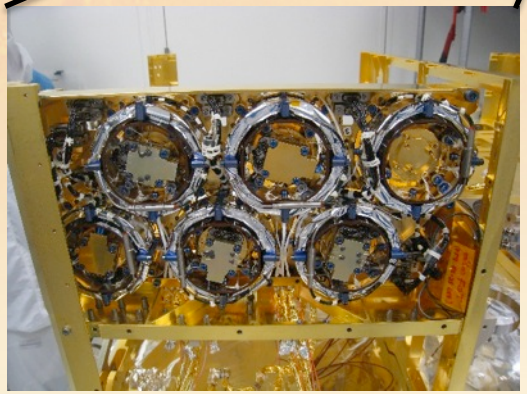


Quadrupole Mass Spectrometer

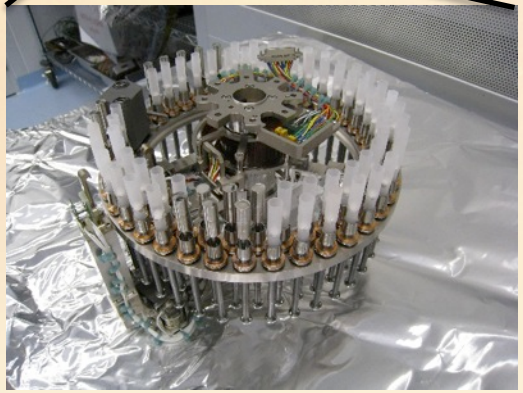




Tunable Laser Spectrometer

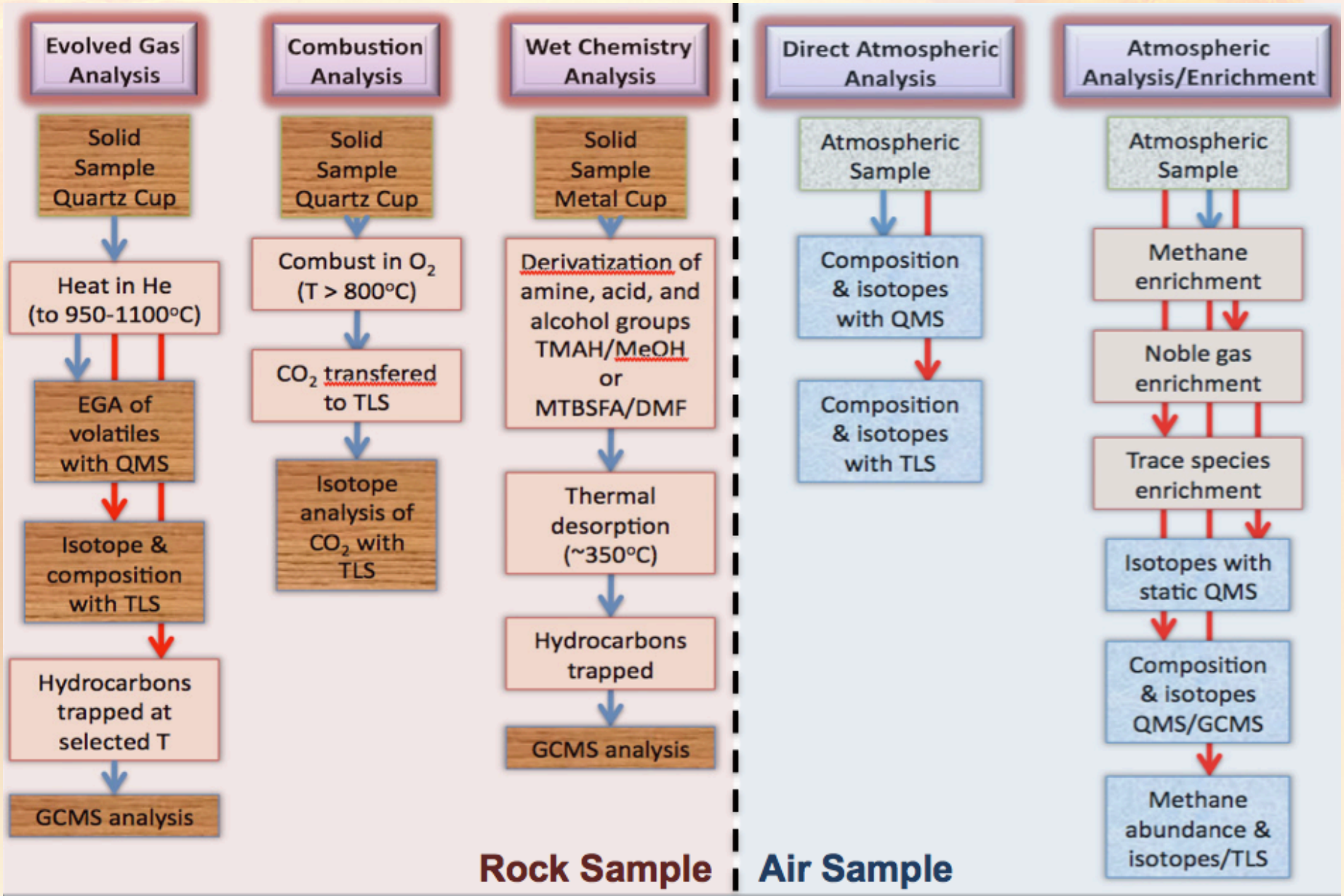


Gas Chromatograph

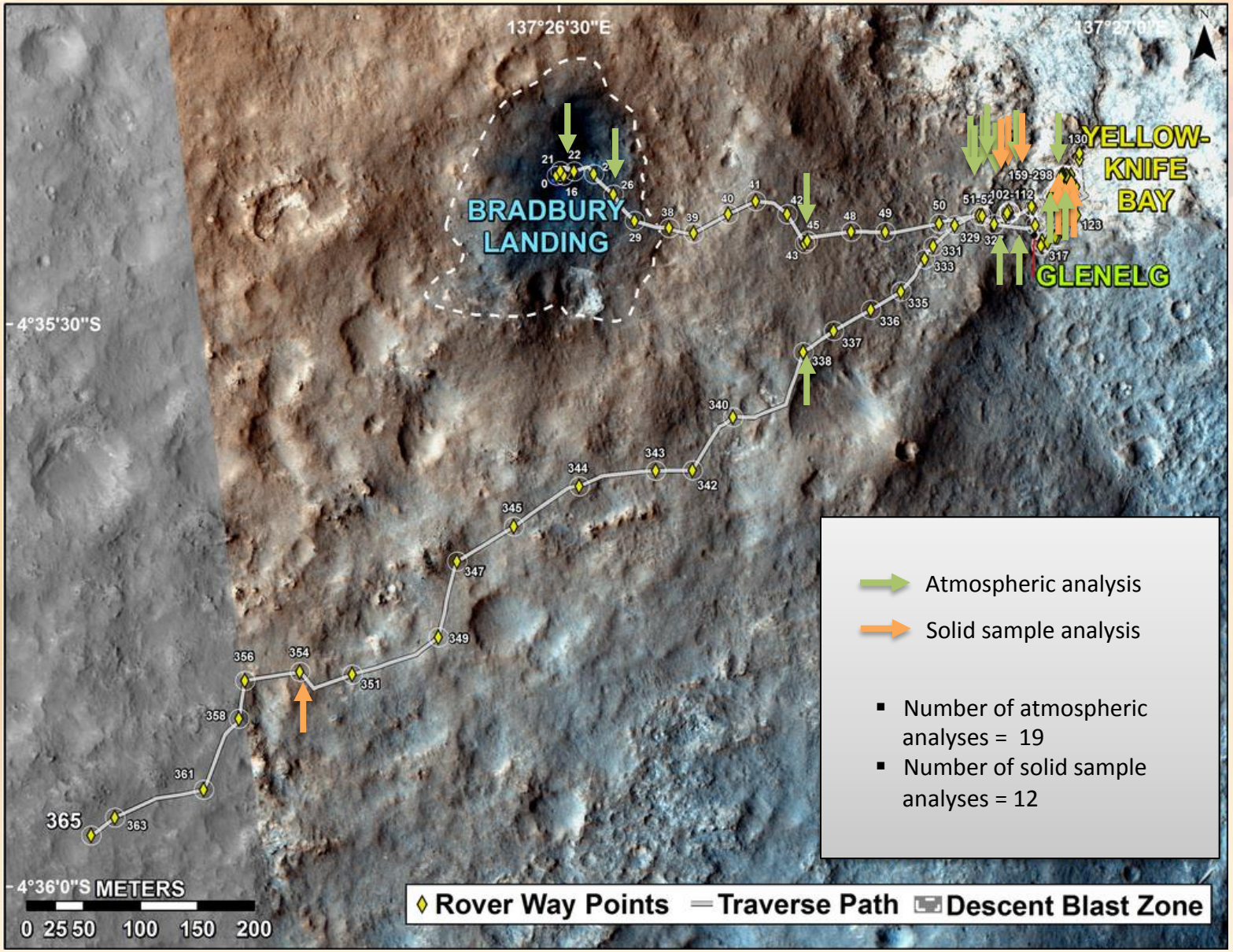


Sample Manipulation Systems

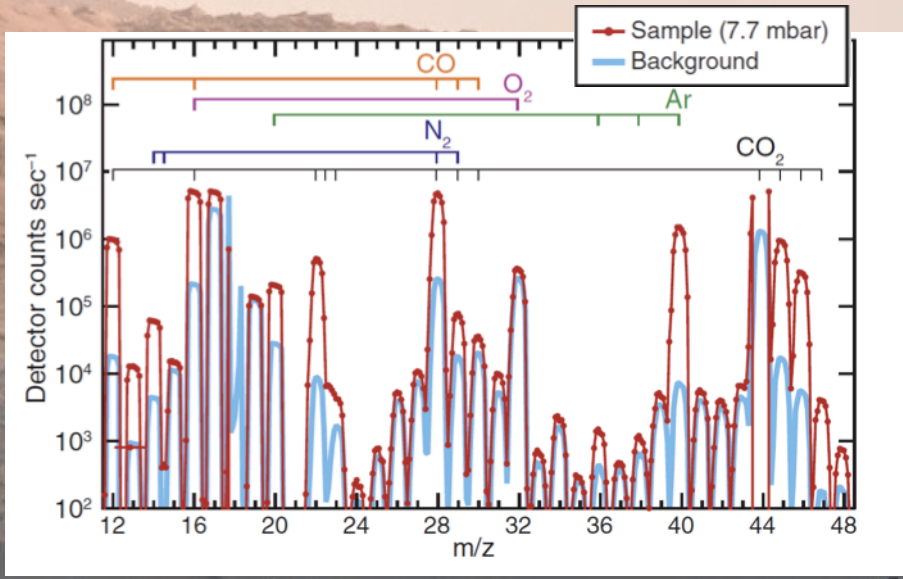
Atmospheric and solid sample Analyses

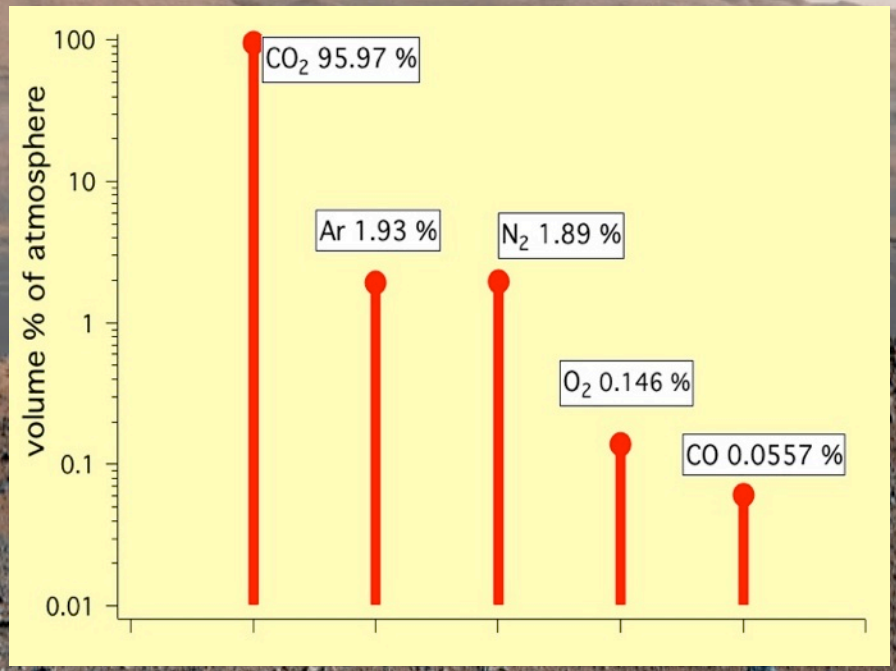


SAM runs (so far…)



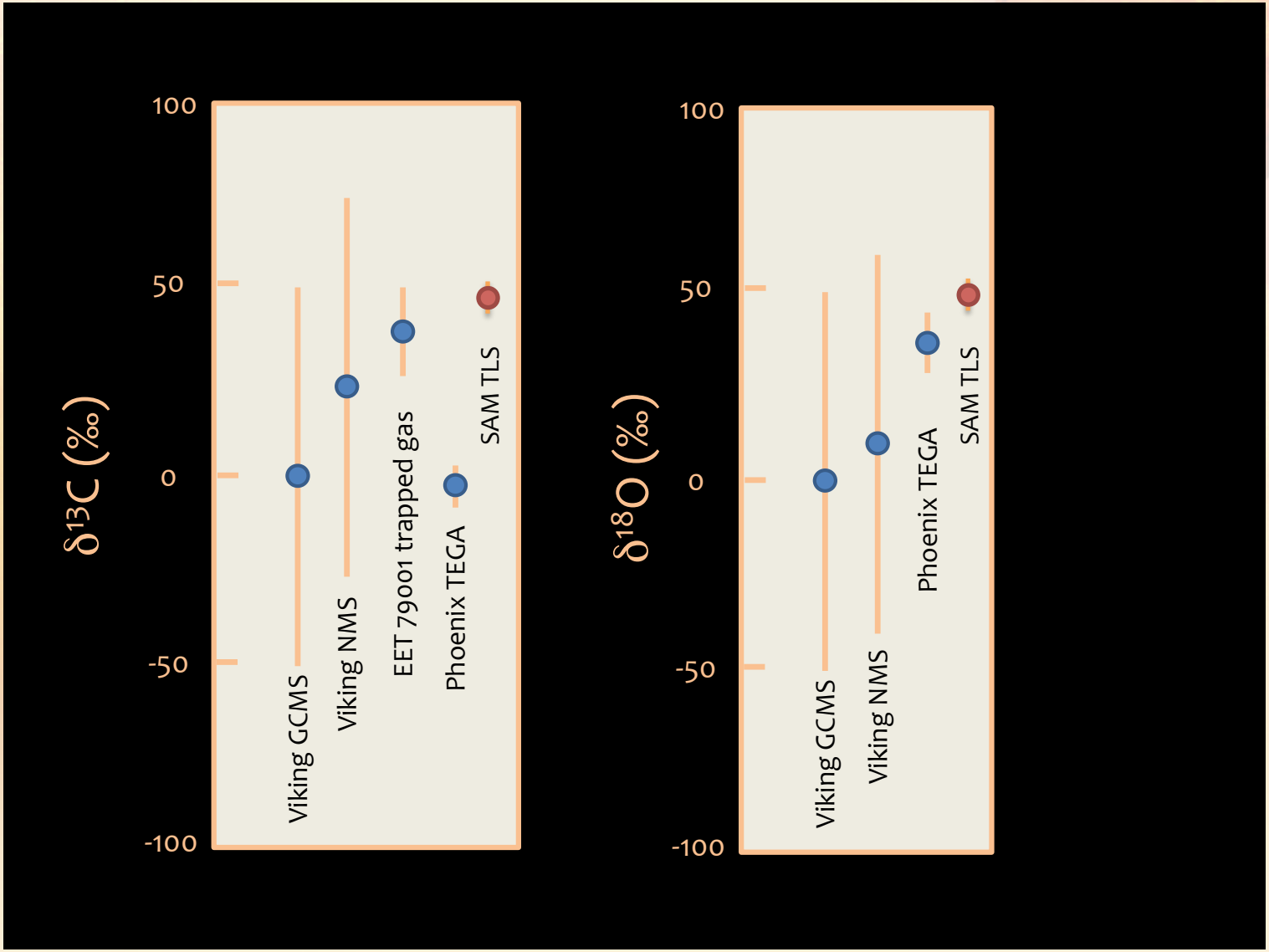
Atmospheric Gas Abundances



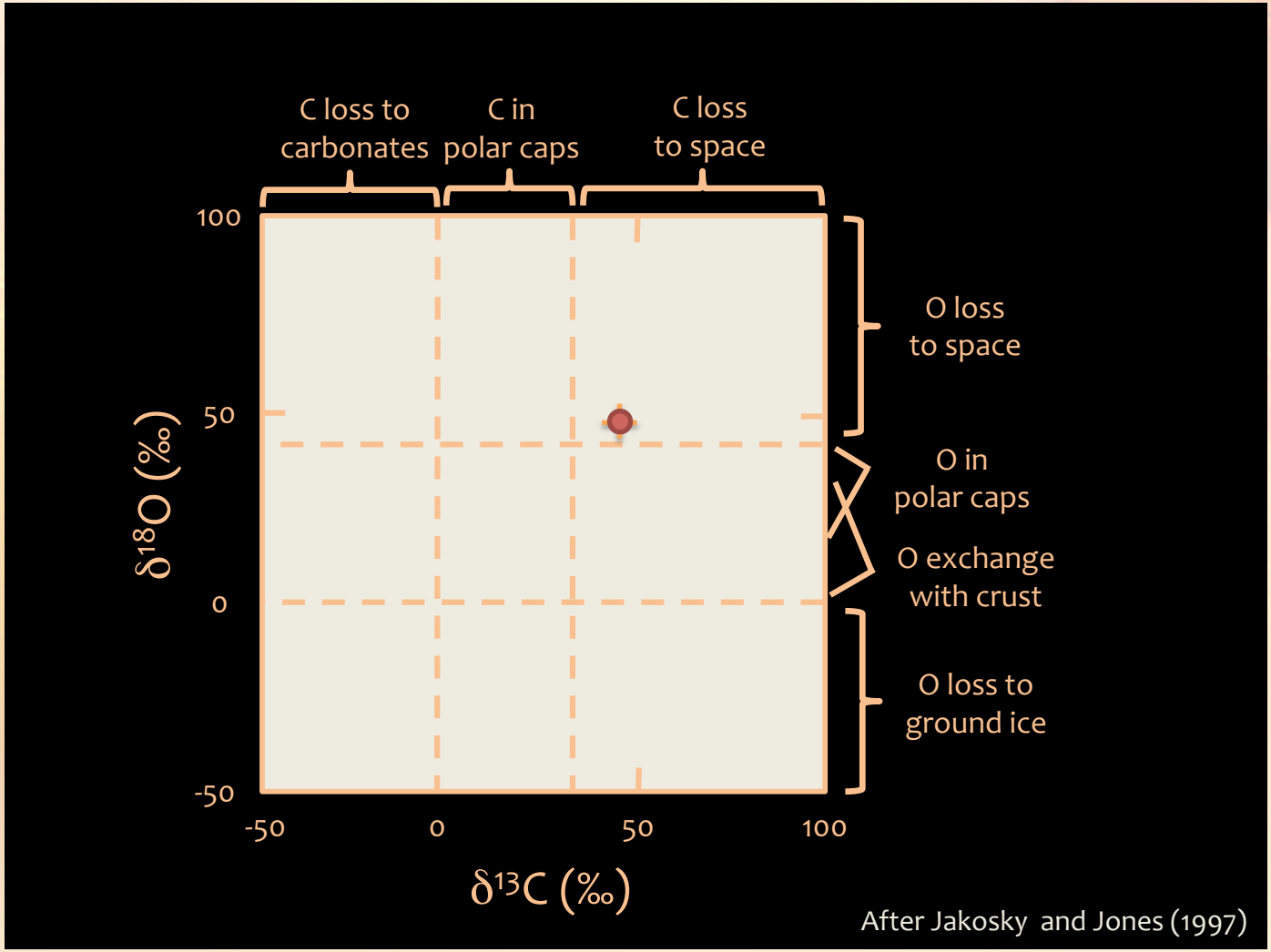


- SAM found that argon, rather than nitrogen is the second most abundant gas.
- Methane has still to be definitively detected (CH_4 < 3.5 ppb).

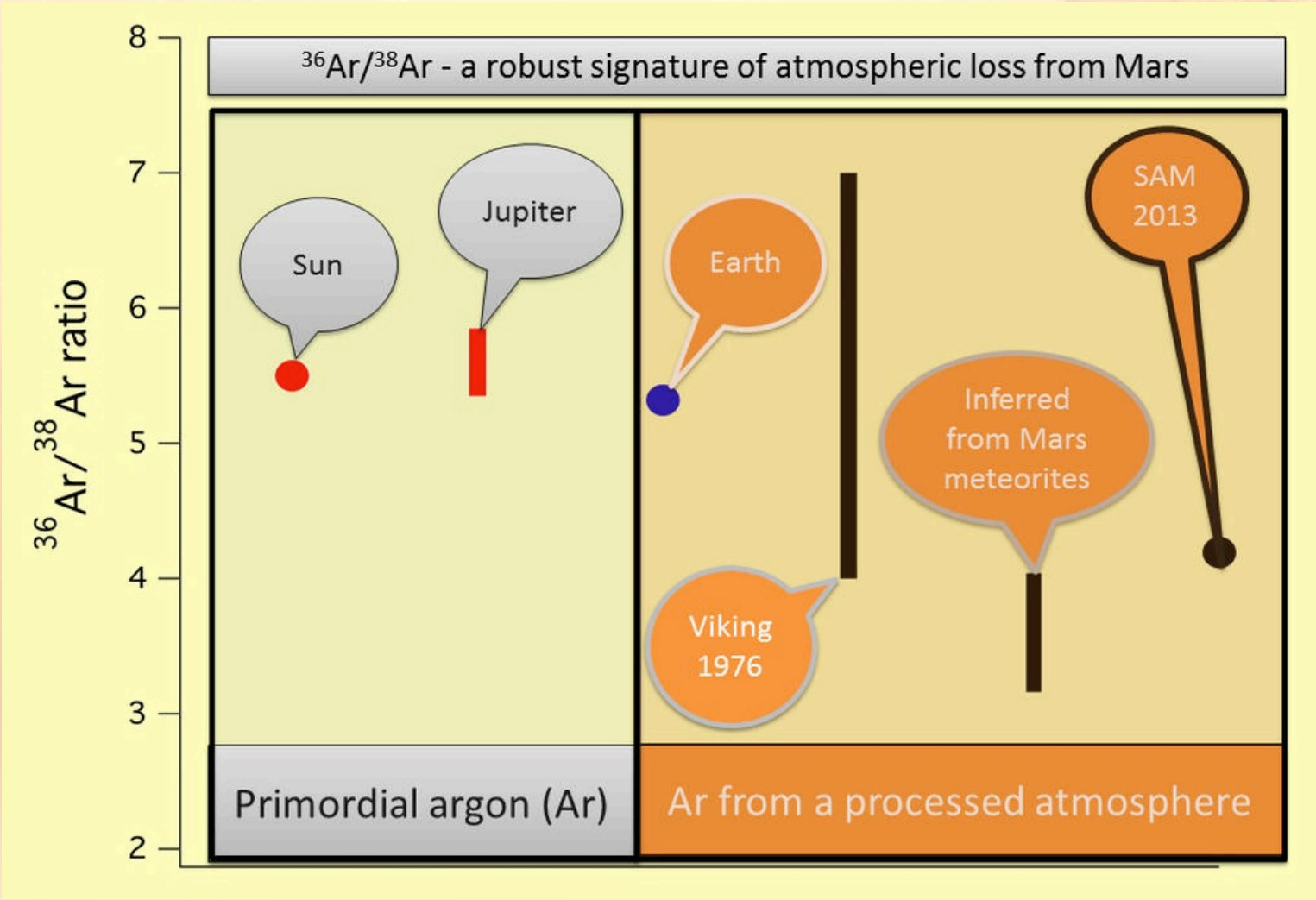
C and O Isotopic ratios



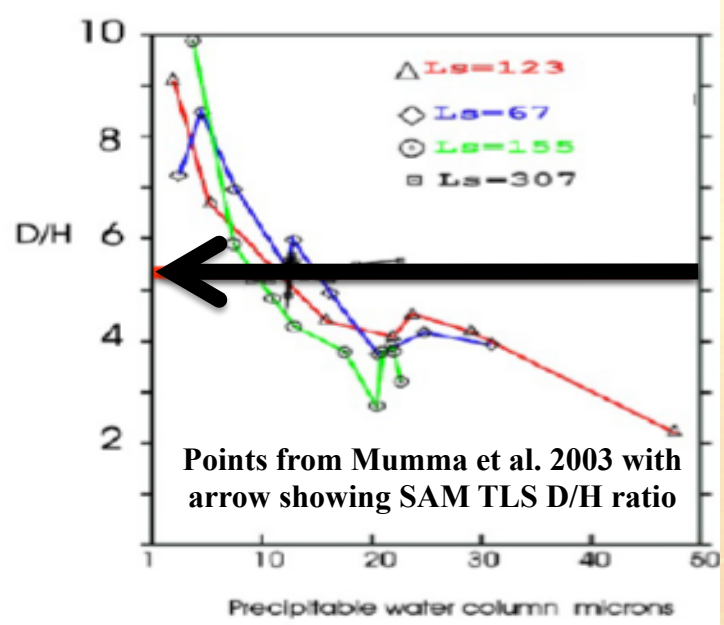
C and O loss process



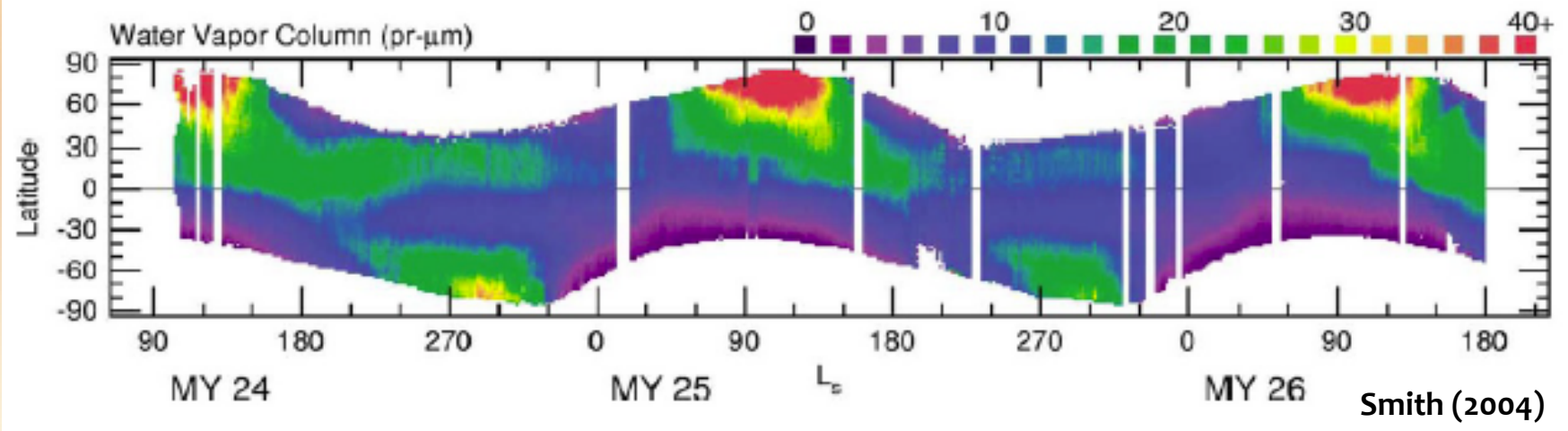
Ar Isotopic ratios



First measurement of Deuterium/hydrogen on the surface Mars



- D/H is one of several isotope ratios used to track the extent of atmospheric escape and the change from early environments
- D/H varies with column abundance (left) and season (below). Rocknest D/H may represent seasonal average



More atmospheric measurements to come

- Atmospheric enrichment experiments
  - $^{15}N/^{14}N$
  - Heavy Noble gases (Kr, Xe)
  - CH_4
- Measurements of diurnal and seasonal variations of atmospheric composition

In-situ data from MSL support the hypothesis of substantial atmospheric loss, dominantly to space

MAVEN will provide the data needed to determine the extent and the chronology of this atmospheric loss

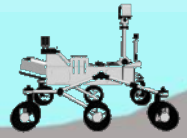
Constraining the climate history of Mars

MAVEN - Part II:

- Current state of the upper atmosphere
- Current rate of loss to space
- Integrated atmospheric loss

MSL - Part I:

- Current state of the atmosphere
- Current atmospheric exchange with surface reservoirs
- Ancient atmospheric records in rocks



MAVEN – MSL Synergy

MSL measures composition of gas at the bottom of the atmosphere

MAVEN measures composition on gas at the top of the atmosphere

Integrated look at the present-day atmosphere and escape processes

MSL measures composition of ancient atmosphere in Rocks

MAVEN measures the impact of variation of the driving processes on escape rate

history of the atmosphere

They will even chitchat