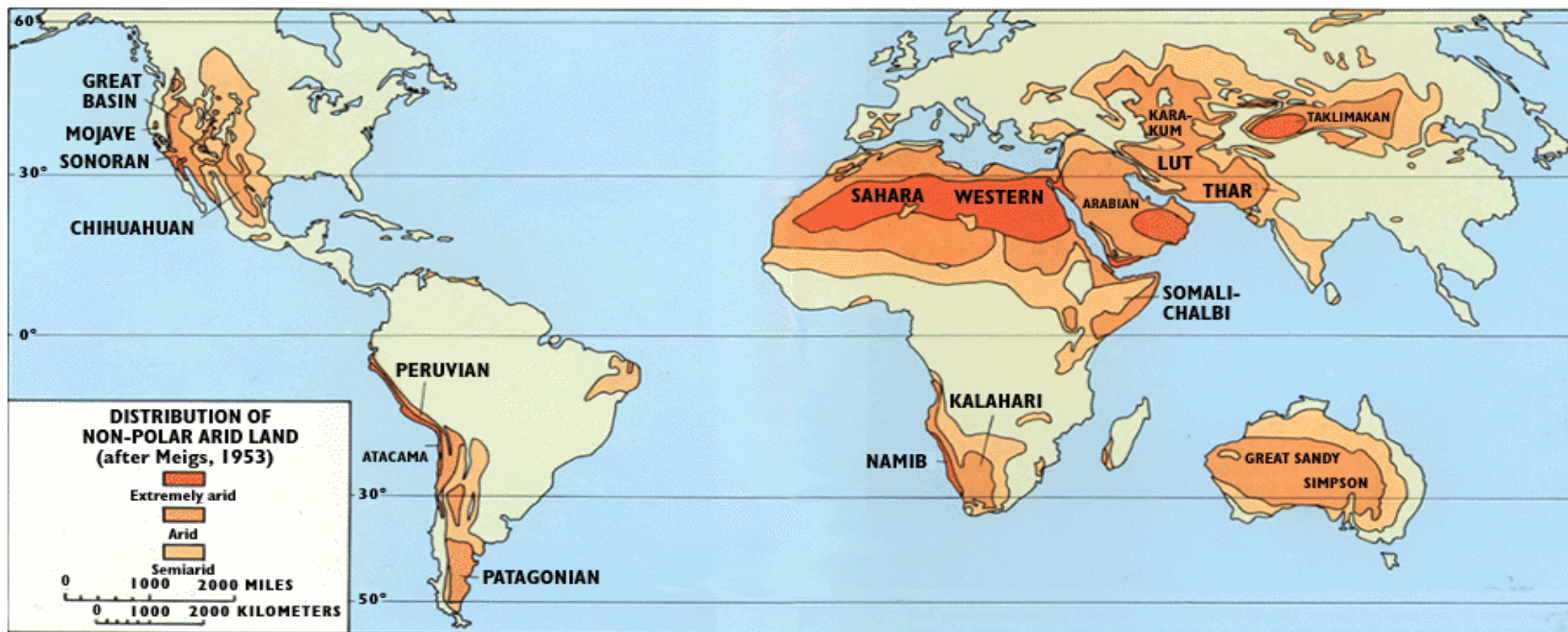


~~Analog~~s

Shallow Life

Disclosure: Until this week “deep” = 1-2m

Hypothesis: The last surface microbial communities on Mars were desert-dwellers



High elevation Dry Valleys (frozen regolith)

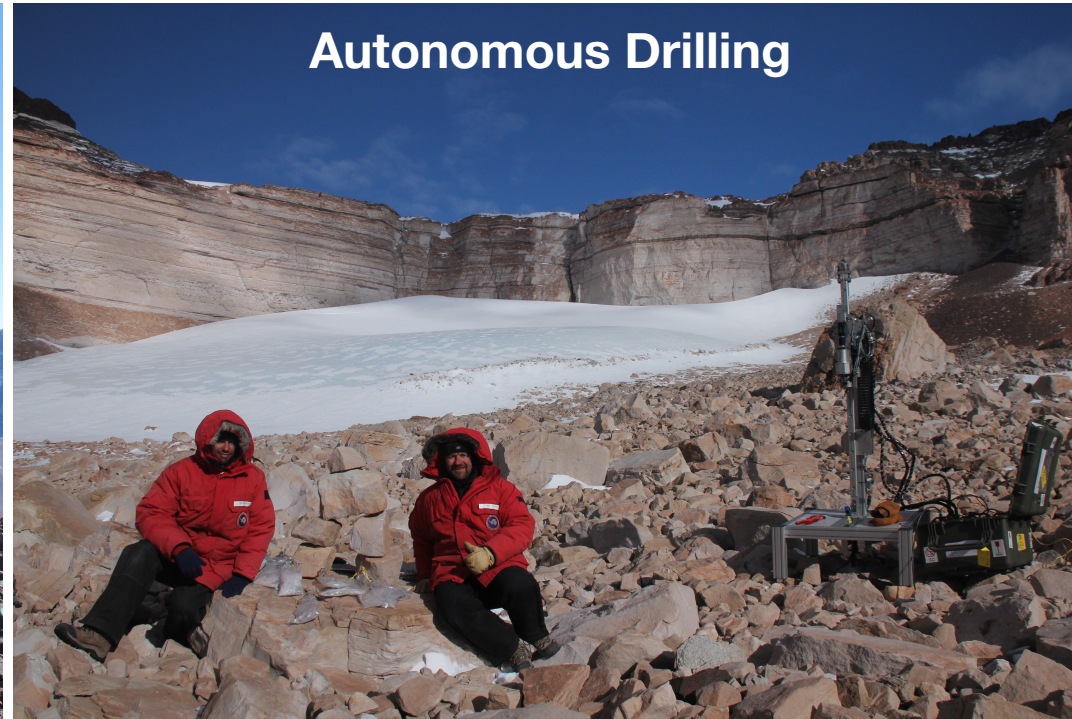
Hyperarid core of the Atacama (soils/salt)

High Elevation Dry Valleys

Site Selection



Autonomous Drilling



- No signs of microbial activity in permafrost soils (**Cold limit of habitability?**)
- Microbial communities hiding away inside sandstone rocks (endoliths)
- Significant horizontal and vertical **variability** in ice content, geochemistry and biomass.
 - * Different **types of ground ice** (vapor-deposited; buried glaciers; frozen snow; frozen lakes...)
 - * **Ice content** can vary by >50% over 10s of cm (at least in the top few meters).
 - * Extremely low levels of biomass that decrease with depth

Hyperarid core of the Atacama (soils)

Dry limit of habitability



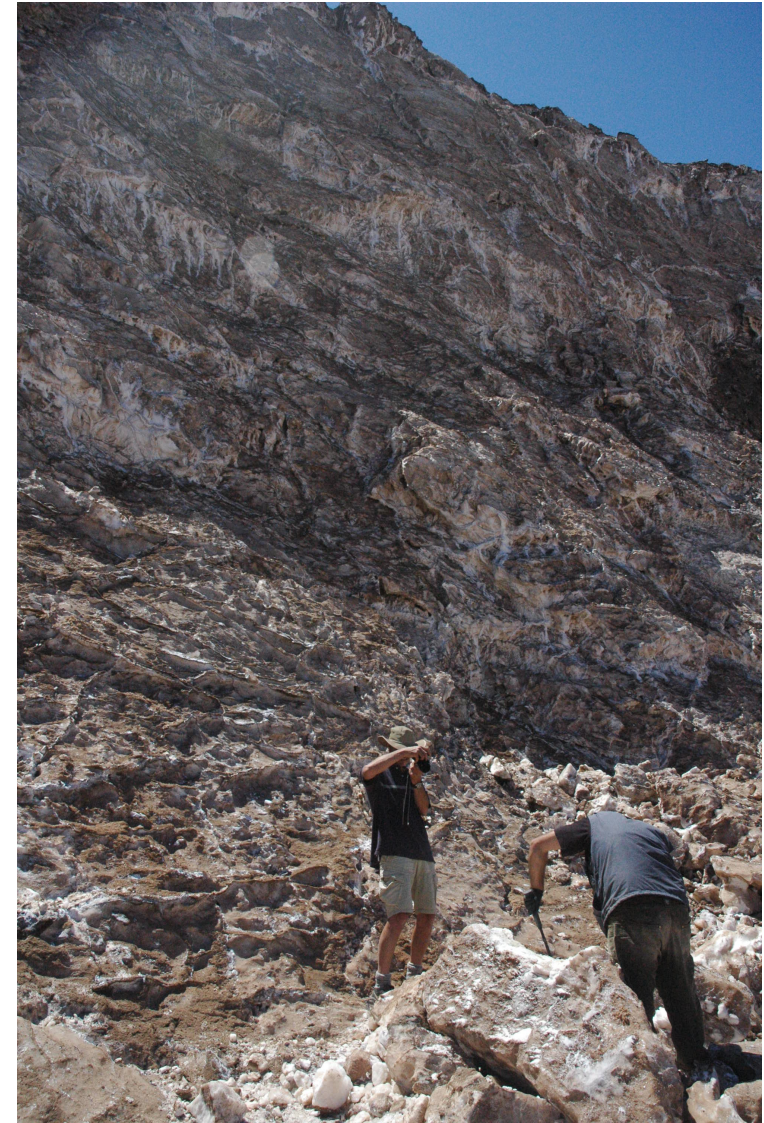
Next generation autonomous drilling

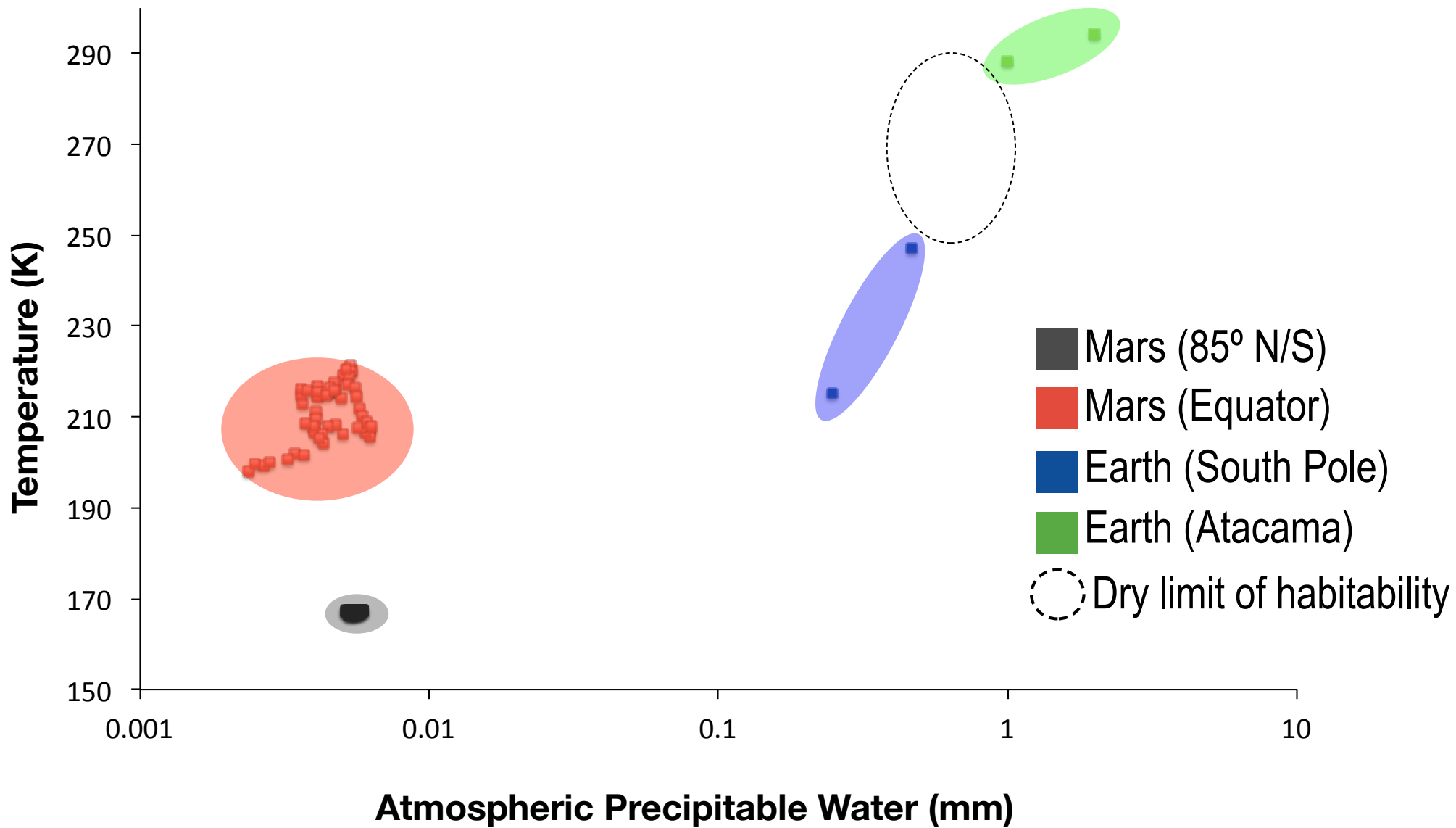


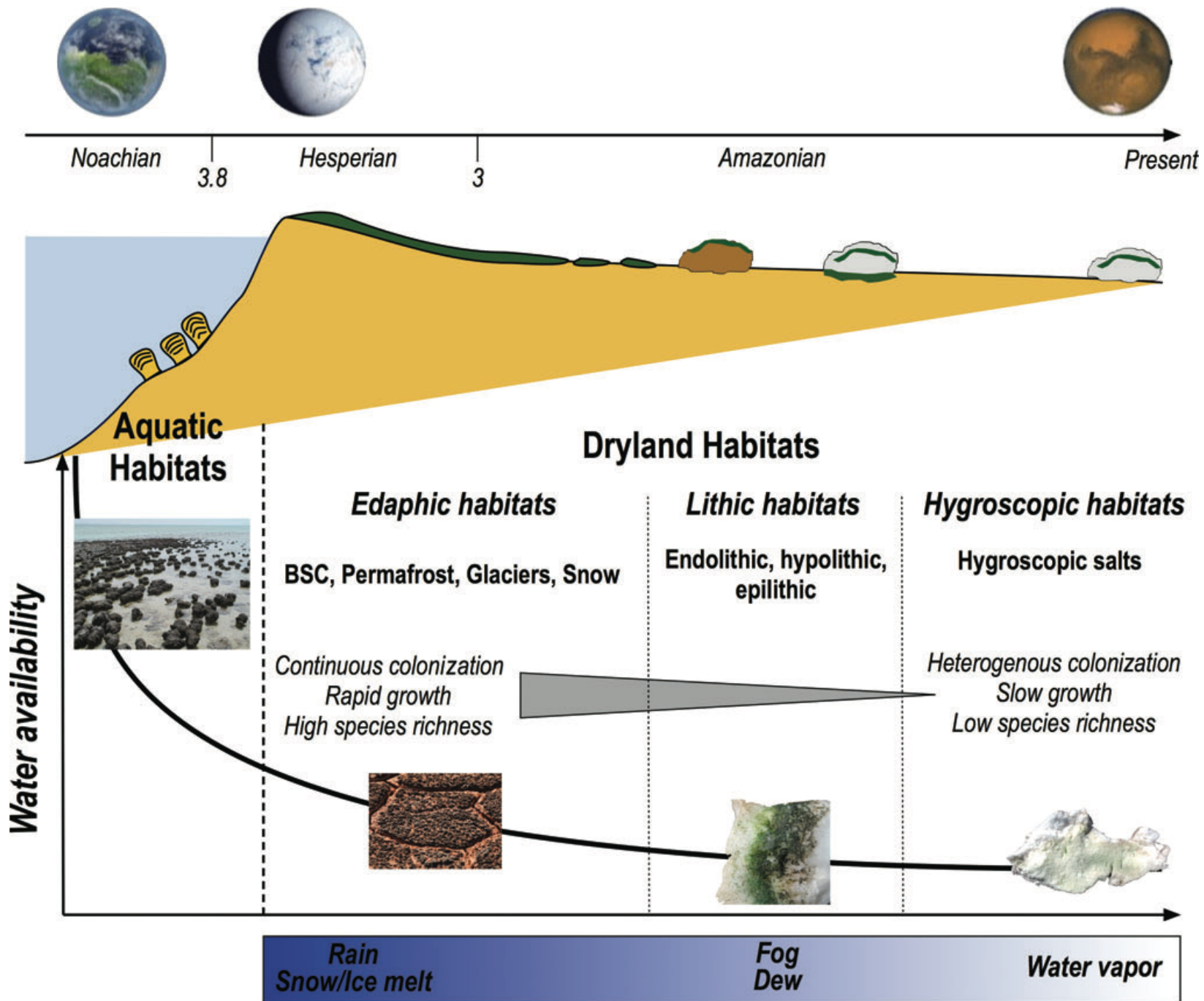
- Lowest biomass soils on Earth. Significant horizontal and vertical **heterogeneity**
- Soil bacteria in survival mode; no growth
- Human and cross-**contamination** are a real and unresolved problem
- Good location to test geophysical tools to detect near-surface aquifers

Hyperarid core of the Atacama (salts)

- Evaporites (playas) are a long-term habitability record (Wet Atacama/Dry Atacama)
- Salts are the last refuge for life near the surface
- Evidence of entombed archaea found in c.a. 2-5 Myr salt layers (very uneven distribution down to 20 m depth)







Takeaways

- **Shallow life** not possible today. Might have been possible in the recent past (Amazonian) but only in localized places (salts/ice)
- Horizontal and vertical variability over 10s of cm in biomass and resources
- Worst-case biomass levels on Earth (Atacama) are best-case biomass levels on Mars (even in the subsurface).
- Reach vs resolution —> The search for evidence of life will likely demand fine sampling resolution (uneven distribution of biomass over short vertical/horizontal scales). The extraction of resources (water) will likely require reach (maximize extraction volume)
- “**Intelligent drills**” needed for decision making (fast interpretative telemetry that provides clues regarding the nature of subsurface materials) — also applies to ground ice
- 1-10 vs 100-1000

Life detection requires stringent molecular contamination control

