Workshop Without Walls: Upstairs Downstairs

Breakout Group 3 Note-taking

Debate #3: Is O2 a definitively useful biosignature?

Context is important:

- abiotic and biotic processes look a lot alike, difficult to tell the difference between them without the context
- Habitable zone is useful for context, because it retains its water within the limits between water-loss at inner edge and outer edge
- We would need to know planet's location within the HZ, as well as volcanic outgassing inputs to the atmosphere. need to know something about temperature
- Where planet is in its evolution (early-on could start evaporative water-loss)

What is biosignature for Archaean Earth (before rise of oxygen)?

- Methane is only detectable one we have come up with
- Other contributions to atmosphere would be in too small amounts to be detected

*If we have methane + what? = no life
*if we have an atmosphere rich in methane and CO, CO will build up if we don't have way to remove it (i.e. biogenic process)

*so maybe "look" for lack of CO?
→ but hard to detect, esp. with first generation direct imaging mission

Methane may not be a given biosignature of Archaean environment

What do we need to predict the reductant flux of an exoplanet?

- how big is the planet's core?
- for a given density, how does the core vary
- model how mantle differentiated, could tell us about mantle redox state?
- core sizes from better mass, radius, and host-star abundance data

*statistically we would expect an Archaean-like environment to be younger, because once photosynthesis develops it seems likely to dominate (age of planet important?)

*Can you predict redox state of the mantle if you are given Mg, Si, O, Fe, H?

- There are competing models
- Generally, two ways to oxidize the mantle
    - using water cycling through

    - or take FeO(+2) → FeO which sinks and Fe(+3) perovskite
    - (why we think Mars mantle is more reduced than Earth)

*global coverage, surface signatures that you might be able to see in one pixel
(different sized stars → different peak of photosynthesis so different colored organisms, red-edge of chlorophyll could be different on exoplanets)

- reflected spectrum of plant leaves, chlorophyll A (oxygenic photosynthesis)
- for other planets, could an-oxygenic photosynthesis use pigments that would reflect at different wavelengths, and a signal that could be detected from space?
- narrow down to purely biotic signatures and not mineral signatures, needs work

*presence of lifetime in ammonia could be representative of something? if observed then it would mean it has a large source, because it is otherwise short-lived in the atmosphere
→ (but some of these gases have different lifetimes if a planet around M-star)

*Question of 2 billion year detection for oxygenic photosynthesis on Earth?

- obviously depends on the instrument you use to detect
- not undetectable, but could miss it on first pass, like with first gen. direct imaging