

Things that go BOOM in the night

Mike Way
NASA Goddard Institute for Space Studies

What Makes a Planet Uninhabitable
<Habitability Spectrum>

Earth IS the canonical ‘habitable spectrum’ planet

- Since Hadean: Long periods of habitability
- Short periods of conditions hostile to life
  - Snowball/slushball, impactors, volcanism, orbital dynamics
  - Could be tipping points to long-term uninhabitability?
- We must compare MORE to Earth through time rather than just modern Earth

Not another Impactor talk!

- We tend to assume that impactors are the final arbiter of habitability
  - Reasons? Humans!

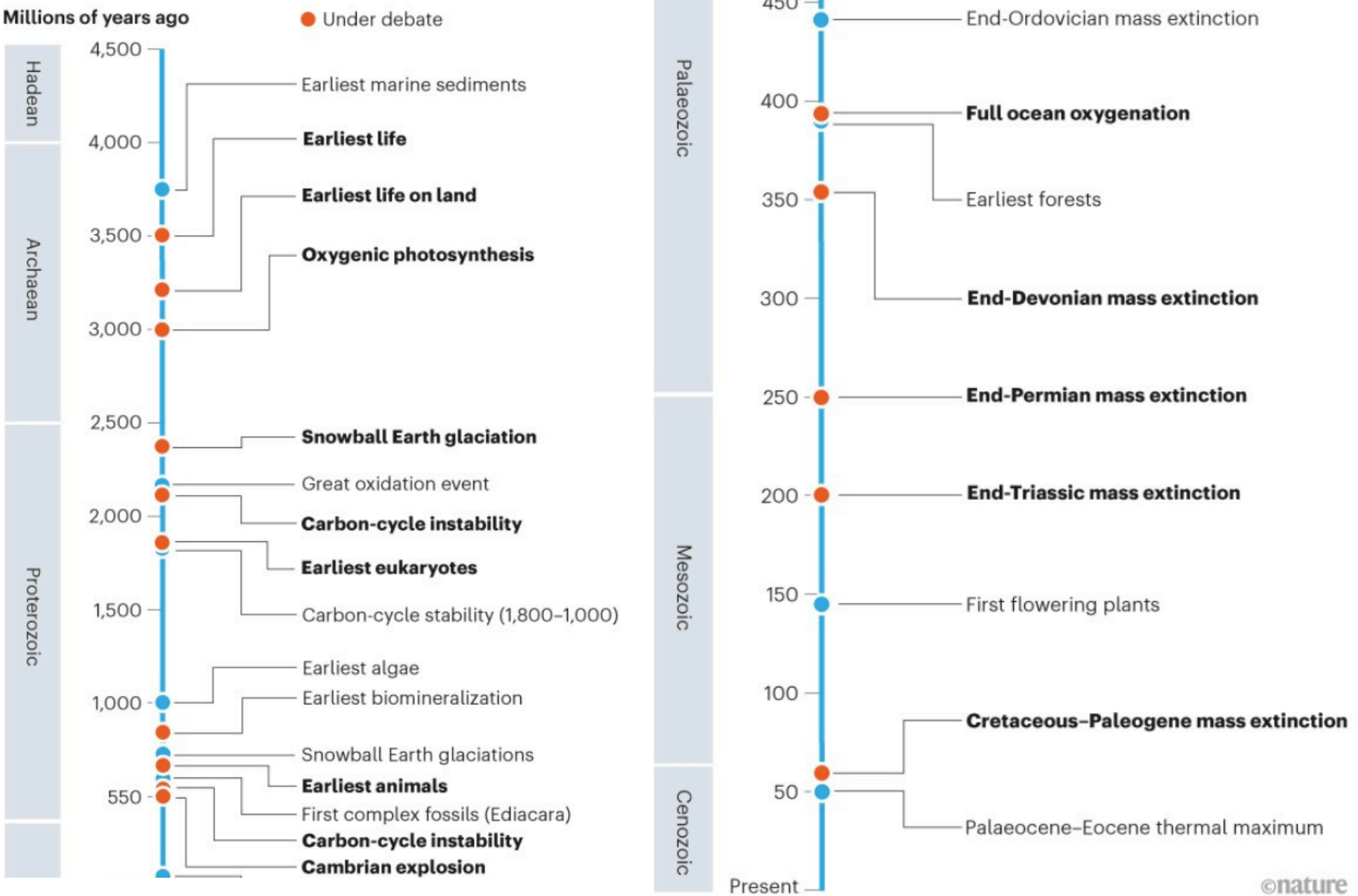
- Are there other factors to consider regarding long term habitability?

Problems with current thinking?

- Contentious timelines play their part
  - Planavsky et al. 2020 Nature 581, 137

CONTENTIOUS TIMELINE

Earth's environmental history has been reconstructed with data wrestled from ancient rocks. Some events remain hotly debated. Archiving and sharing of rock samples enable published work to be tested and replicated.



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Problems with current thinking?

- Contentious timelines play their part
  - Planavsky et al. 2020 Nature 581, 137

- Contentious science plays its part, e.g.
  - Hard Snowball versus Slushball?

Hard Snowball Earth



Or Slushball Earth?



Problems with current thinking?

- Contentious timelines play their part
  - Planavsky et al. 2020 Nature 581, 137
- Contentious science plays its part
  - Hard Snowball versus Slushball?
- Human bias plays its part?
  - May not be so useful when considering long-term 'habitability' in exoplanetary science

Problems with current thinking?

- "*Despite much searching, there remains only one confirmed example of a bolide impact coinciding with an extinction event*."
  - Bond & Grasby 2017 "**On the causes of mass extinctions**", Palaeogeography, Palaeoclimatology, Palaeoecology Volume 478, 3-29

But Impactors are so appealing!



Always include a T-rex!

Always include a giant fiery ball!

Post giant fireball



Another T-rex

Don’t forget the humans!!

Include the occasional volcano = **BANG #1**



T-Rex AGAIN!

BANG #2

Overlooked Large Scale Volcanism

Large Igneous Provinces

- Responsible for dramatic climate change
- Responsible for mass extinction events
- The biggest baddest ones?!
  - Siberian Traps = End Permian (252Ma)
  - CAMP = Central Atlantic Magmatic Province
    - End Triassic (200Ma)
  - Deccan Traps = End Cretaceous (65Ma)
    - Extinction non-avian dinosaurs?

When will the Earth try to kill us again?

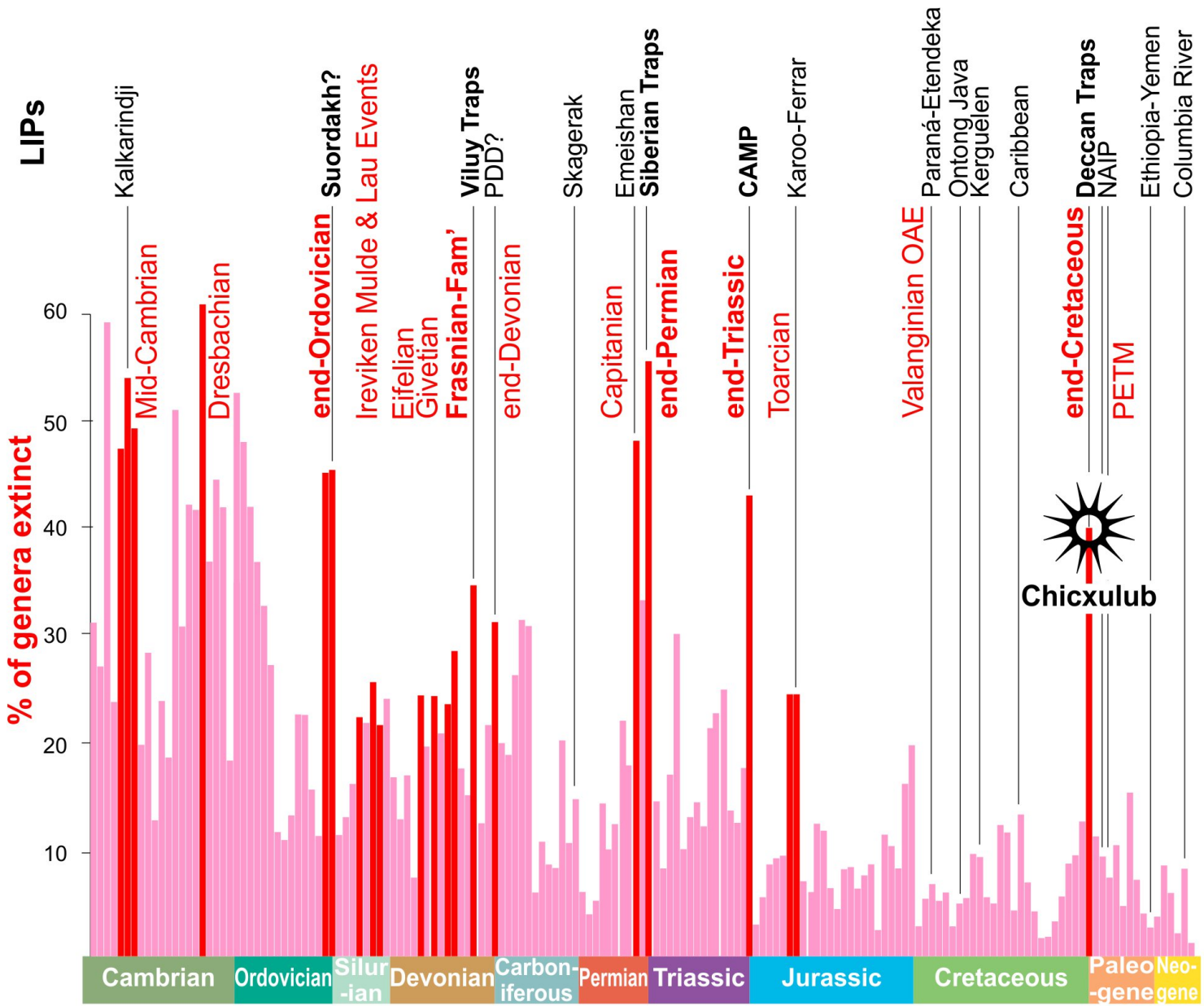
Most mass extinctions began with vast convulsions of Earth's interior—can we detect that?

HOWARD LEE - 11/9/2017, 1:00 PM

Arstechnica.com November 2017



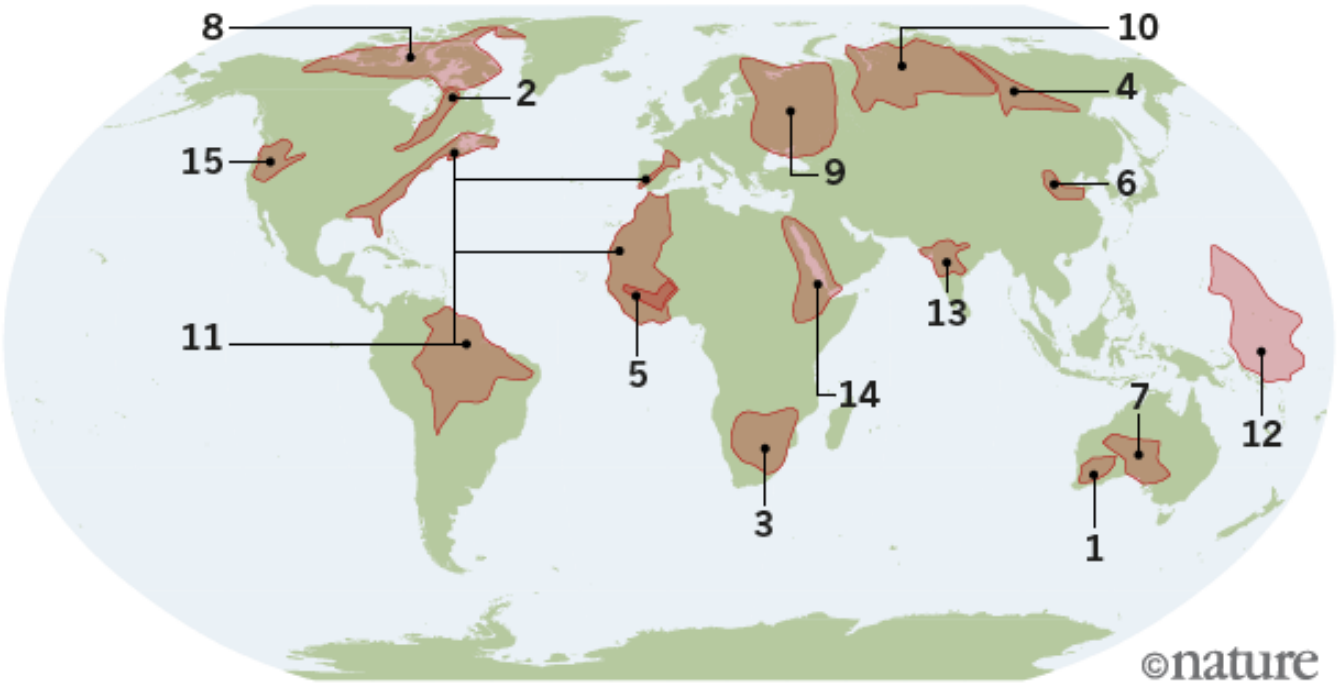
Large Scale Volcanism is a CONSTANT throughout Earth's history and appear to be random events=> HAVE WE BEEN LUCKY?



EARTH'S BIGGEST ERUPTIONS

Scientists have extended the geological record of massive volcanic eruptions, uncovering evidence for world-changing events that occurred more than 2 billion years ago.

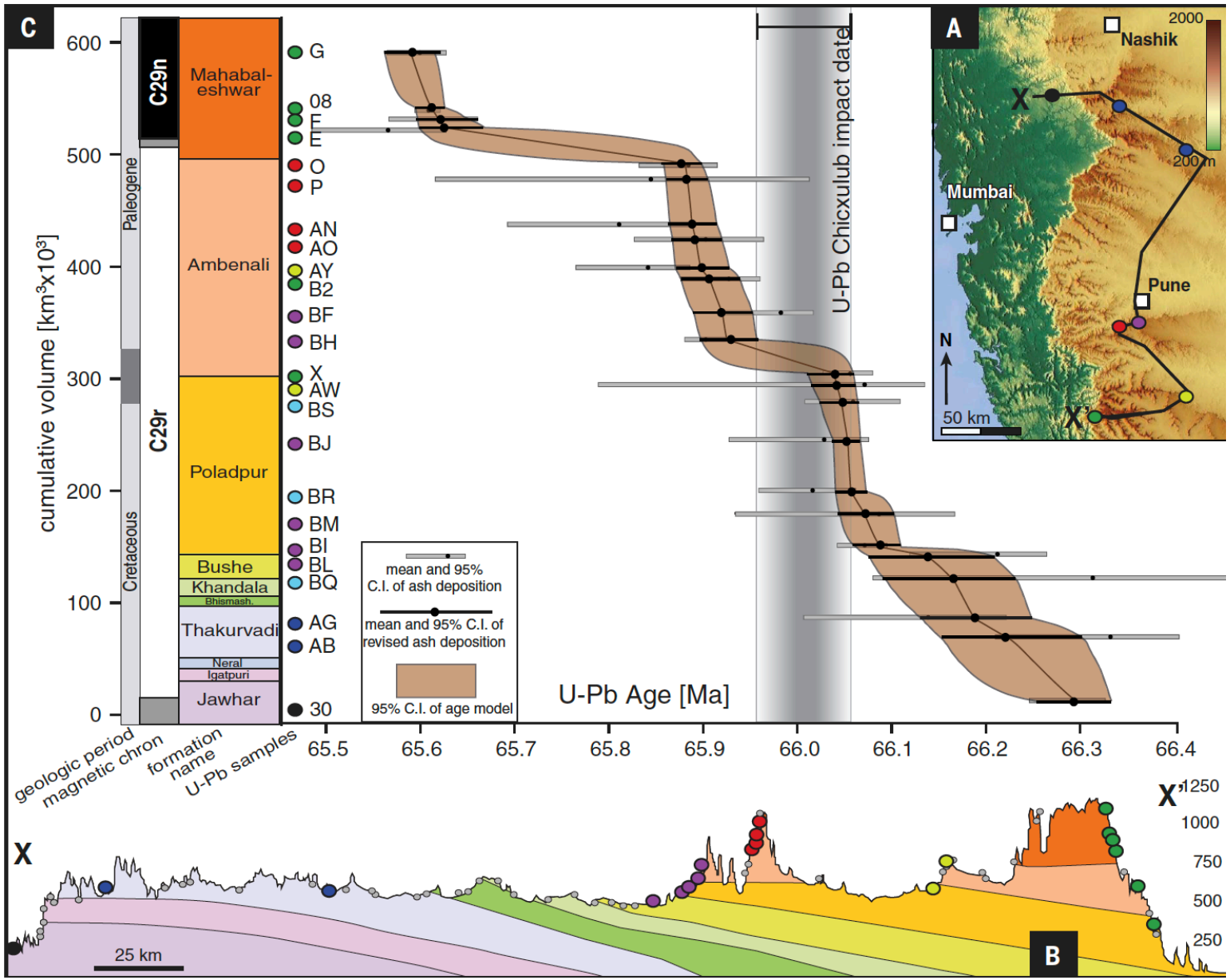
Eruptions, showing extent of lava flow



1. **Widgiemooltha** 2.42 billion years
2. **Ungava** 2.22 billion years
3. **Bushveld** 2.05 billion years
4. **Timpton** 1.75 billion years
5. **Essakane** 1.52 billion years
6. **Dashigou** 920 million years
7. **Gairdner** 820 million years
8. **Franklin** 725 million years
9. **Kola–Dneiper** 370 million years
10. **Siberian Traps** 252 million years
11. **Central Atlantic Magmatic Province** 200 million years
12. **Ontong Java** 120 million years
13. **Deccan Traps** 66 million years
14. **Afro–Arabian** 30 million years
15. **Columbia River** 17 million years

It CAN be both volcanism & bolide

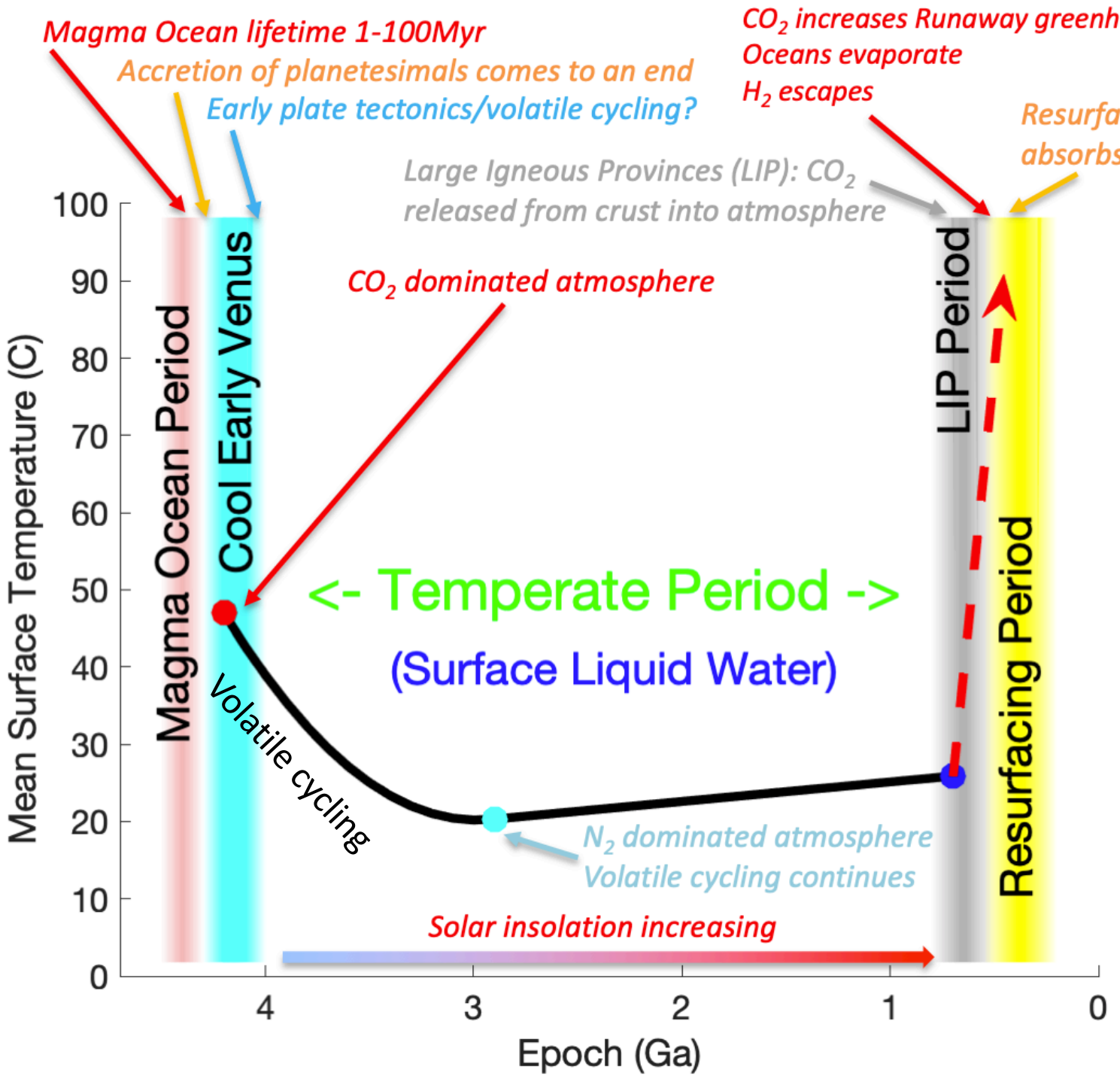
Schoene et al. 2019 Science: Deccan Traps & Chicxulub



Is Venus the other canonical 'habitable spectrum' planet?

- Magma Ocean lifetime ~few Myr?
  - Need exoplanet observations (Lichtenberg)
- Slowly rotating planetary cloud feedback
  - Pollack 1971, Yang et al. 2014
- Did water ever condense on its surface?
- Habitable -> uninhabitable via interior processes?
  - BANG: Simultaneous Large Igneous Provinces?
- If yes, where is the Oxygen?

Speculative Venusian Climate History



Way & Del Genio 2020 JGR Planets
https://doi.org/10.1029/2019JE006276