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# Large Igneous Provinces and Climate

## It's a Trap!

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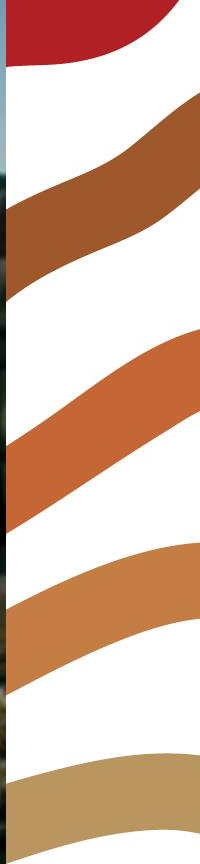


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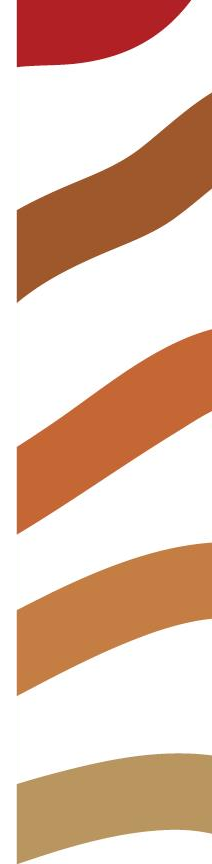
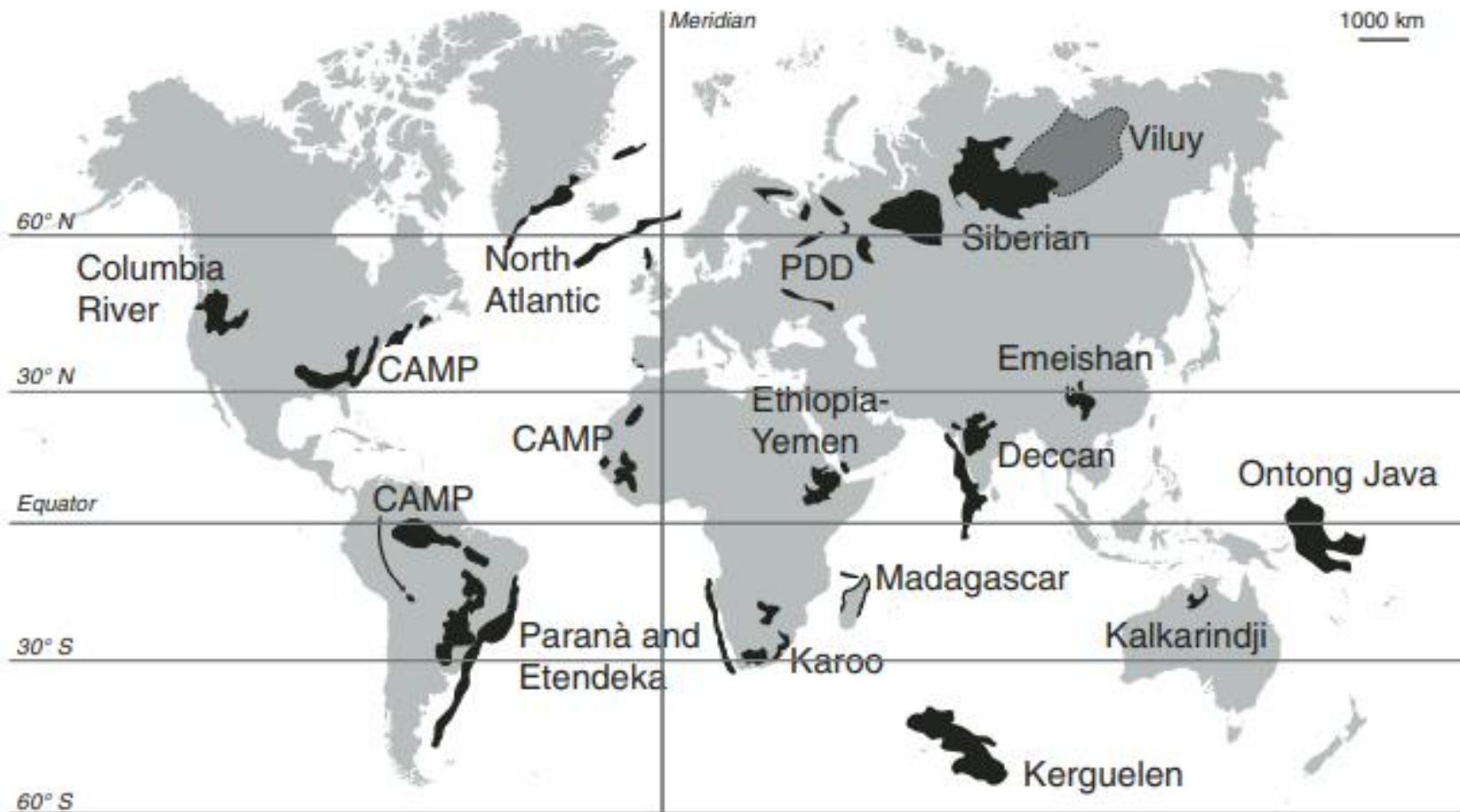
# What are large igneous provinces (LIPs)?

- >100 000 km<sup>2</sup> mafic igneous rock formed over 1 – 5 million years
- NOT a normal eruption
- Underwater or on continents



Basalt flows roughly the area of Iceland or larger are considered LIPs

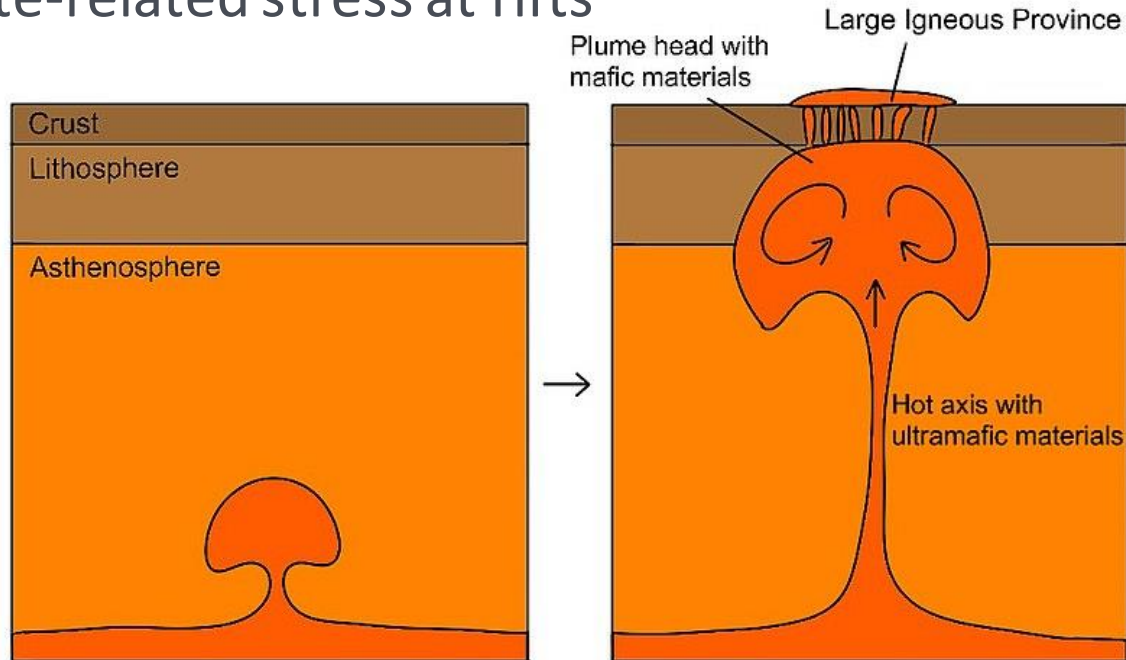




Some of the large igneous provinces (Bond & Wignall 2014, DOI:[10.1130/2014.2505\(02\)](https://doi.org/10.1130/2014.2505(02)))

# Possible causes of LIPs

- Mantle plumes → magma up to 10x of a Mid-Ocean Ridge OR
- Plate-related stress at rifts



# LIP eruption characteristics

- Pyroclastic material
- Degassing of CO<sub>2</sub>, SO<sub>2</sub> and halogens from extrusive and intrusive basalts
- Gases released from heated sedimentary rocks (evaporites and coal)



# How much carbon dioxide do LIPs produce?

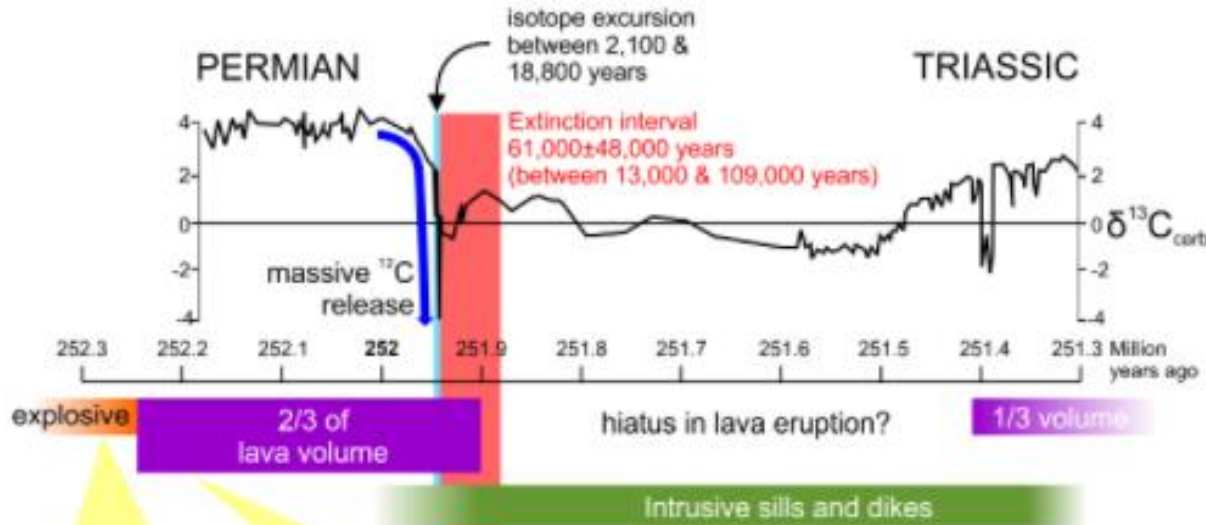
- 200 000 Mt/y CO<sub>2</sub> from CAMP flood basalts (end Triassic) compared to 3 000 Mt/y from normal flood basalts
- This additional CO<sub>2</sub> is from magmas in crust and volatile-rich sedimentary rock

*For comparison...*

- Kilauea averages 3 Mt/y
- Burning of fossil fuels 33 000 Mt/y



# Eruption of the Siberian Traps



Timeline of the End Permian Extinction from Skeptical Science, based on Burgess & Bowring 2015

(howardlee 2015, <https://skepticalscience.com/Burgess-Bowring-2015-Siberian-Traps-Dates.html>)





# Effect of carbon dioxide from LIPs

- **Warming**
- Ocean acidification
- Acid rain
- Ocean anoxia

→ **Extinction**



# Extinctions related to LIPs

| Extinction event | LIP                                      | Extinction of...                       |
|------------------|--|--|
| End Cretaceous   | Deccan Traps*                            | 60% of species                         |
| End Triassic     | CAMP                                     | 76% of species                         |
| End Permian      | Siberian Traps                           | 90% marine, 75%<br>terrestrial species |
| Late Devonian    | Viluy Traps & Pripyat-<br>Dnieper-Donets | 50% of genera                          |

\*Deccan Traps pushed extinction process before bolide impact



# Do LIPs always cause mass extinction?

- No
- Climate effect depends upon:
  - Location of LIP
  - Amount of gas released in eruptions
  - Timescale of gas release
  - Degassing of sedimentary rocks
  - Feedback loops and destabilisation of clathrates





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