Refining the temporal relation between Large Igneous Provinces and carbon cycle perturbations: not every LIP triggers environmental crises, not every crisis is due to a LIP!

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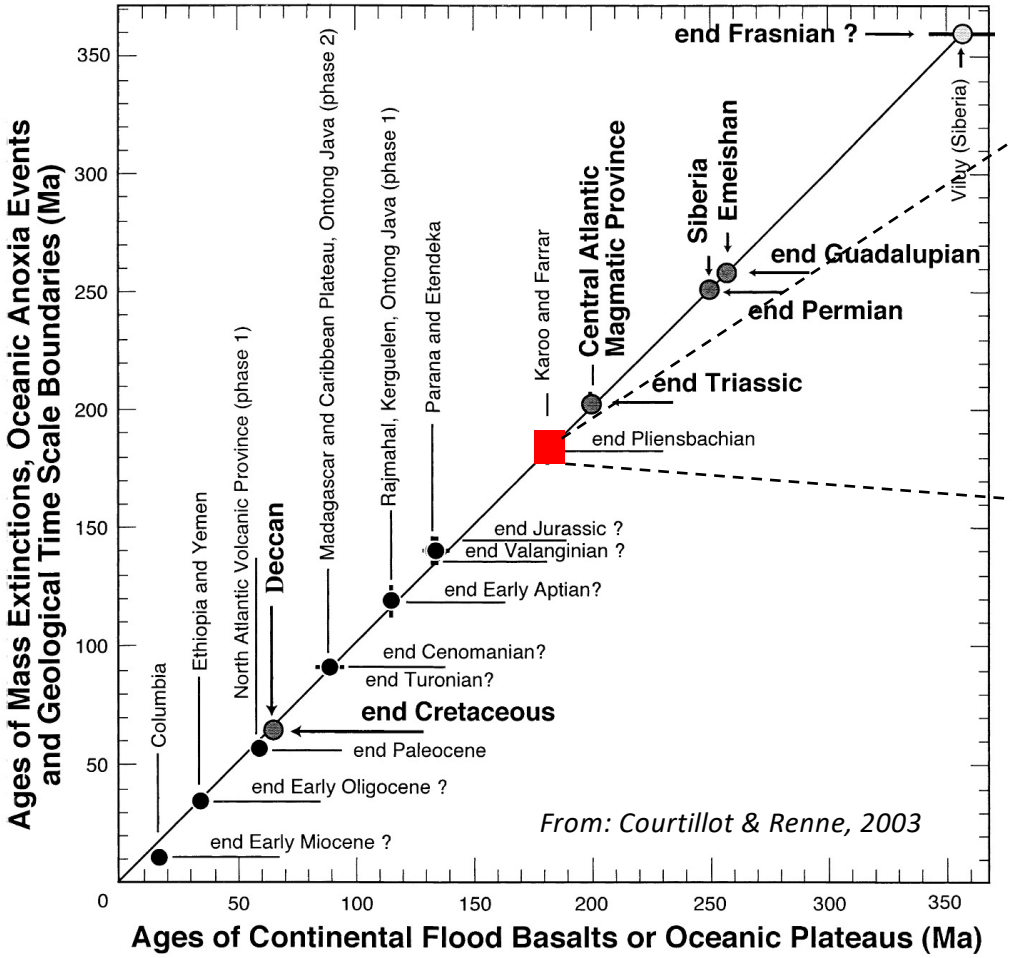
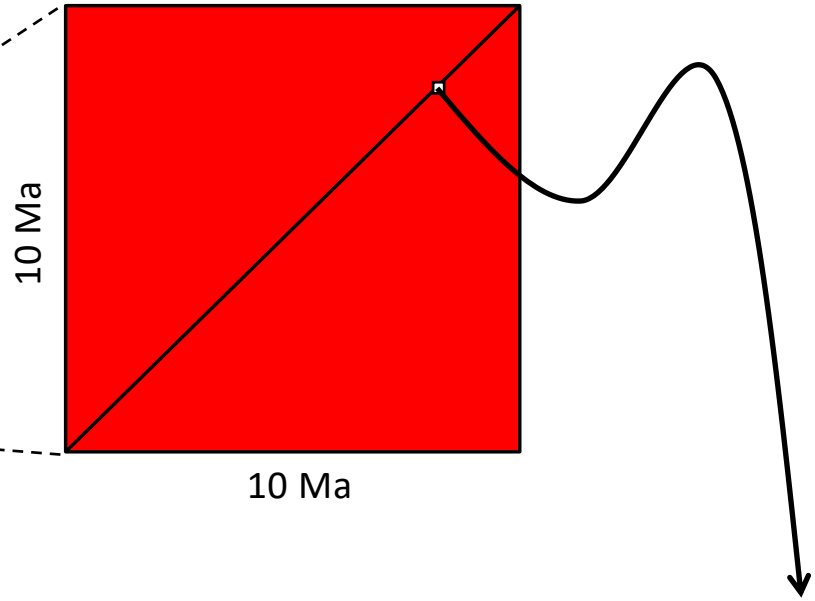
Linking volcanism of Large Igneous Provinces with environmental perturbation and biotic crises at the decamillenial scale

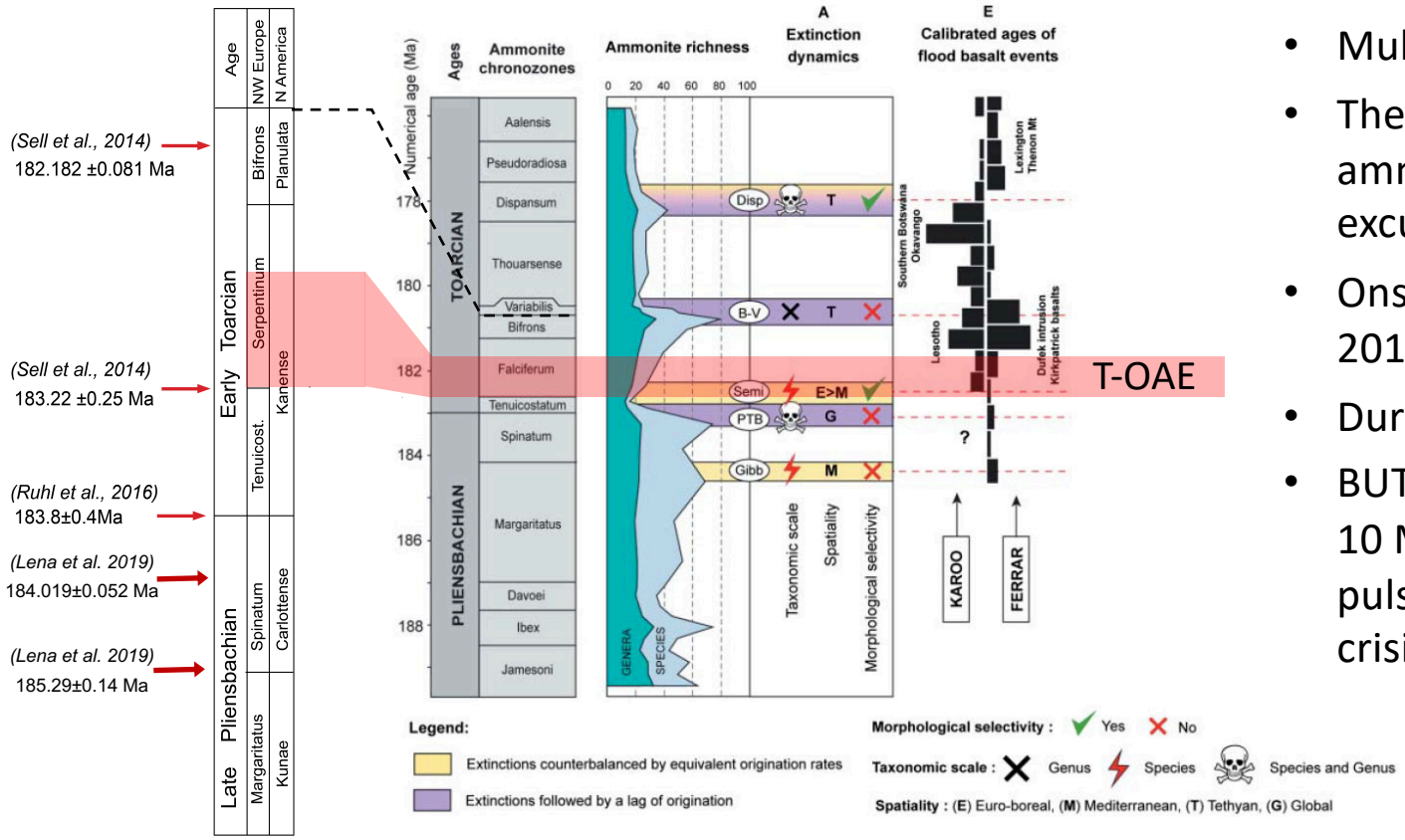




Best precision of CA-ID-TIMS U/Pb dating (~50 ka) for both LIP and extinction dates

Does the temporal coincidence still hold?

Lower Jurassic: Repeated biotic crises – ocean anoxia – LIP activity

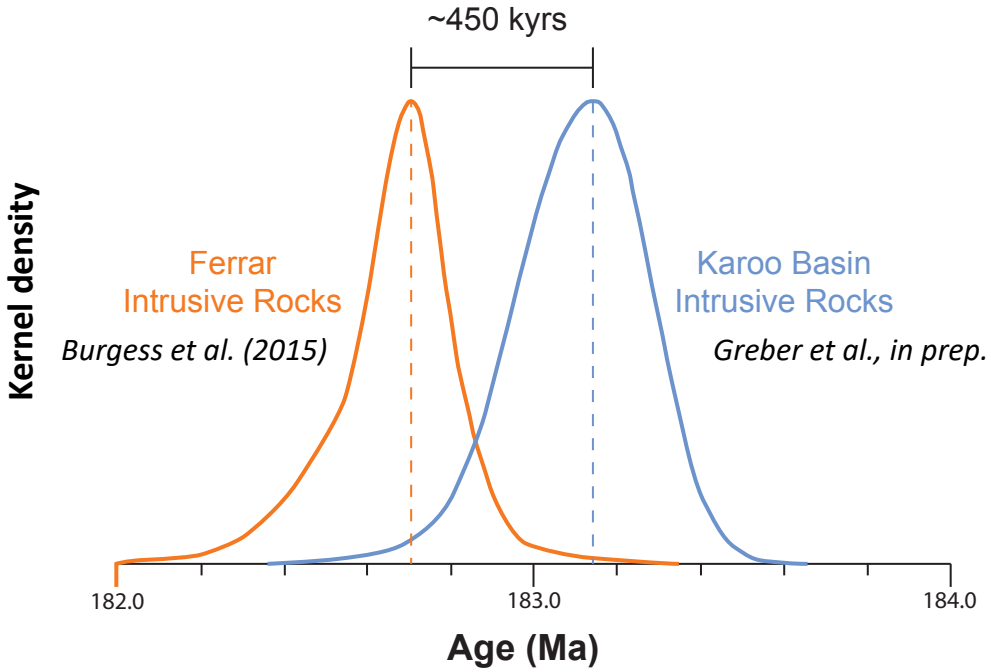


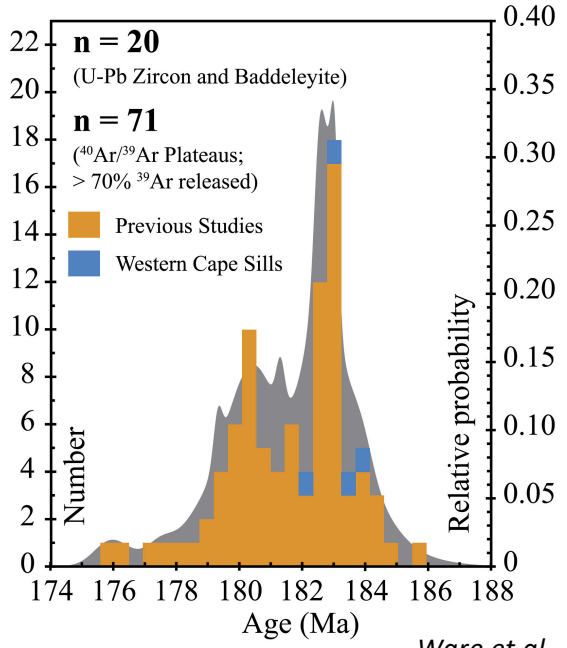
Dera et al., 2010

- Multi-episodic biotic crises in the Toarcian
- The T-OAE is defined by the Falciferum ammonite zone negative carbon isotope excursion (CIE)
- Onset at 183.22 ± 0.25 Ma (Sell et al., 2014)
- Duration 300-500 kyr (Boulila et al., 2014)
- BUT: known Karoo LIP dates scatter over 10 Ma from 186 to 176 Ma – is just one pulse responsible for the environmental crisis?

Karoo sill/dyke complex coincides with onset of T-OAE

- Age of Karoo basin dyke-sill complex is ca. 183 ± 0.1 Ma and correlates with onset of Falciferum ammonite zone negative carbon isotope excursion *(Svensen et al., 2012; Corfu et al., 2016; Greber et al., manuscript in prep.)*
- Continued volcanic activity (Ferrar and beyond?) may be responsible for environmental perturbation
- No volcanic activity pre-183 Ma
- Previously published age scatter ($^{40}Ar/^{39}Ar$ and U/Pb) is at least partly an analytical artefact

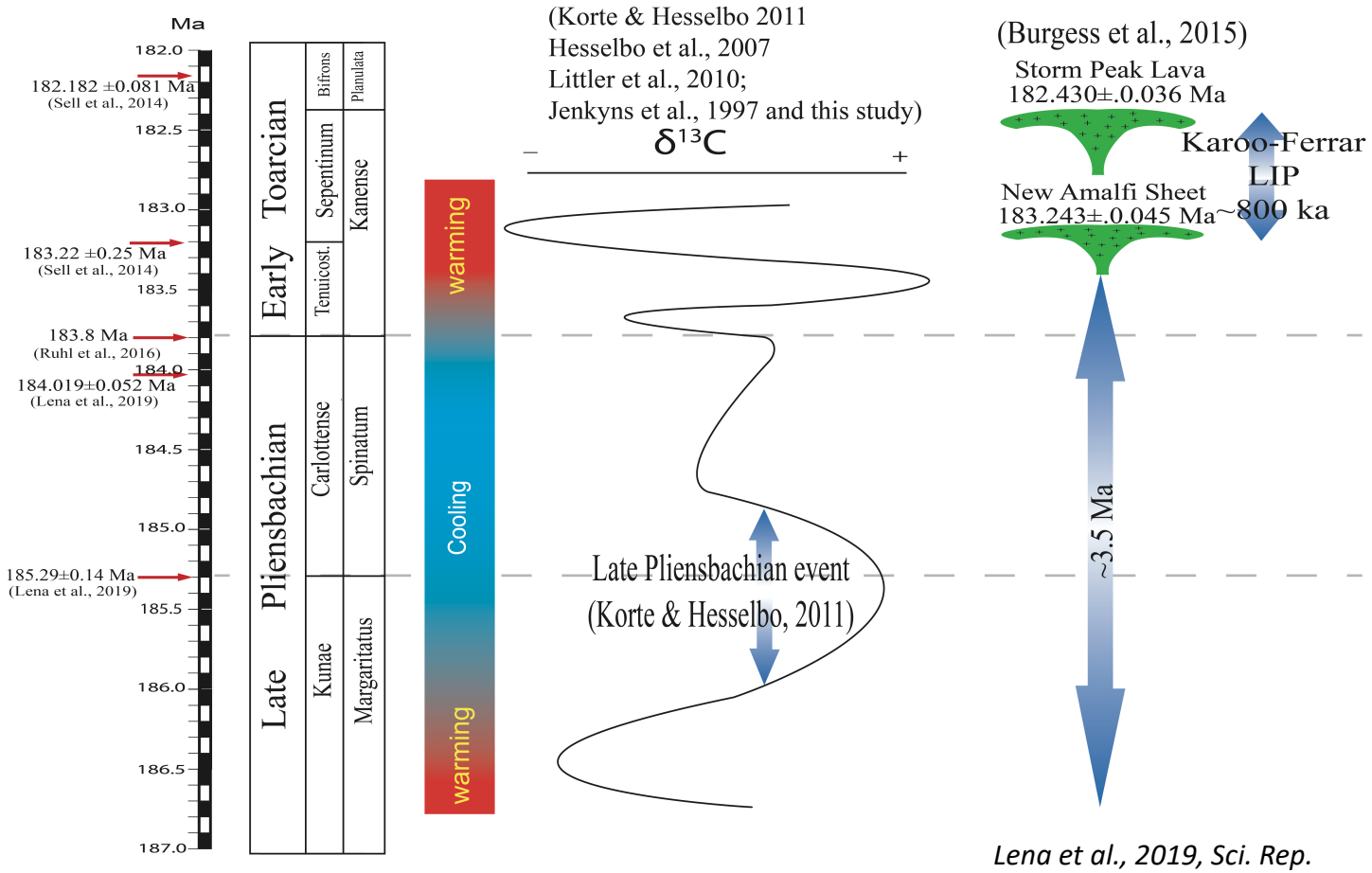




Conclusion: No volcanic driver for the Late Pliensbachian cooling event

Cooling event recorded by C, O, Os isotope time series is older than oldest high-precision age from Karoo LIP

➔ non-volcanic driver for a global C-cycle disturbance



Lena et al., 2019, Sci. Rep.

Conclusions – hypotheses – outlook

- High-precision U/Pb geochronology allows correlation of volcanism with environmental and biotic crises in Earth's history at the ~50'000 years' level of resolution
- Intrusive phases of LIP correlate with mass extinctions
- Periods of massive C-cycle disturbance may have non-volcanic triggers
- Pre- and post-intrusive phase flood basalt phases have less prominent impact on environmental change and biotic crises
- Sill-dyke intrusions into sediments rich in organic matter produce thermogenic CO_2 through from contact metamorphism of sediments *(e.g., Svensen et al., 2004, 2008; Heimdal et al., 2017)*, which seems to be the main driver of environmental change