



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!

Urs Schaltegger¹, Philipp Widmann¹, Nicolas D. Greber^{1,2}, Luís Lena¹, Sean P. Gaynor¹, Torsten Vennemann³, Hugo Bucher⁴

¹ University of Geneva, Department of Earth Sciences, Switzerland

² University of Bern, Institute of Geology, Switzerland

³ University of Lausanne, Faculty of Geosciences, Switzerland

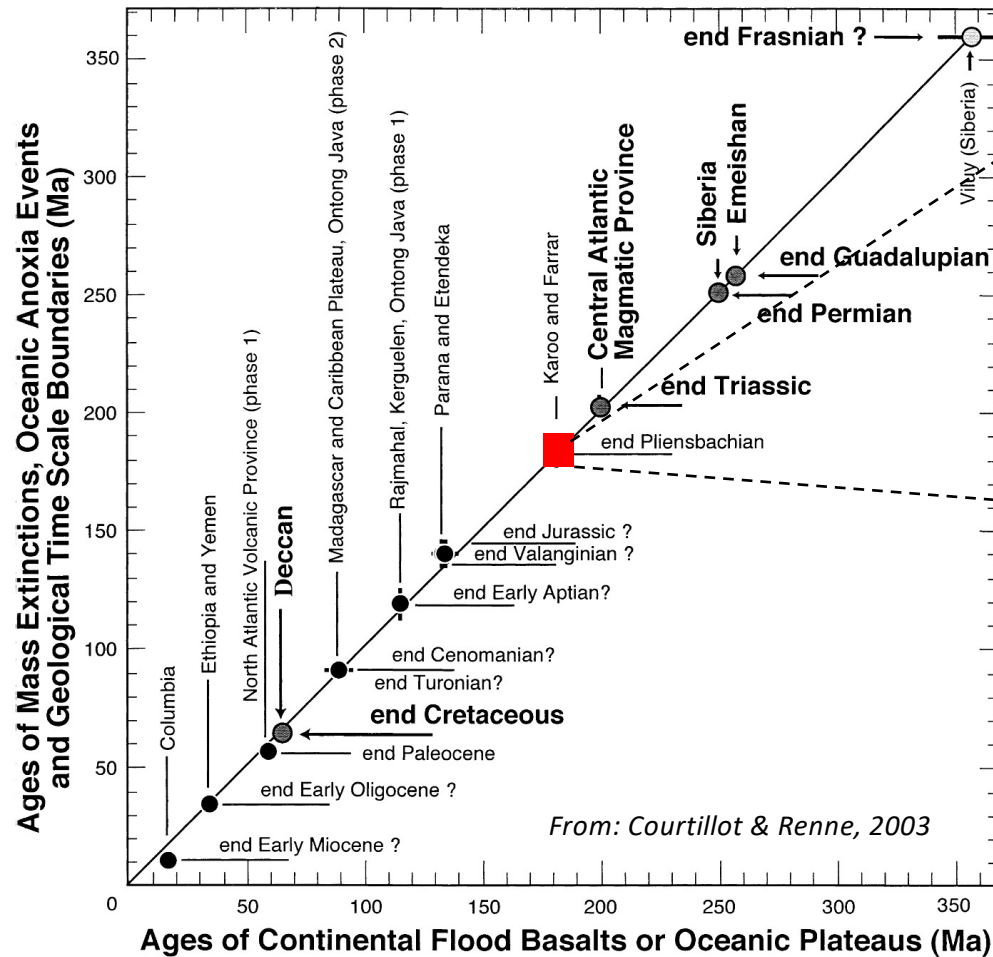
⁴ University of Zürich, Museum and Institute of Paleontology, Switzerland



SWISS NATIONAL SCIENCE FOUNDATION

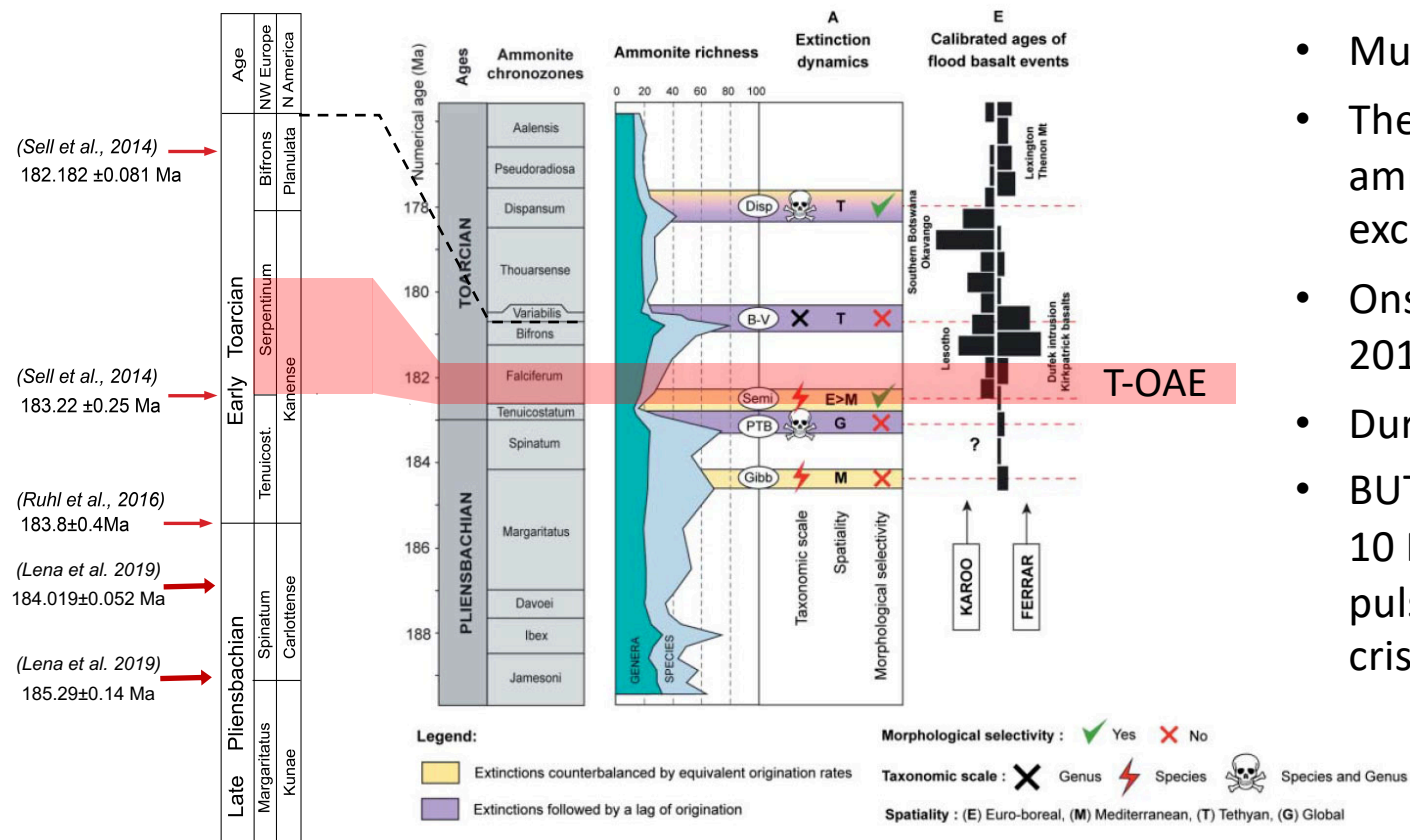


Linking volcanism of Large Igneous Provinces with environmental perturbation and biotic crises at the decamillennial scale



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

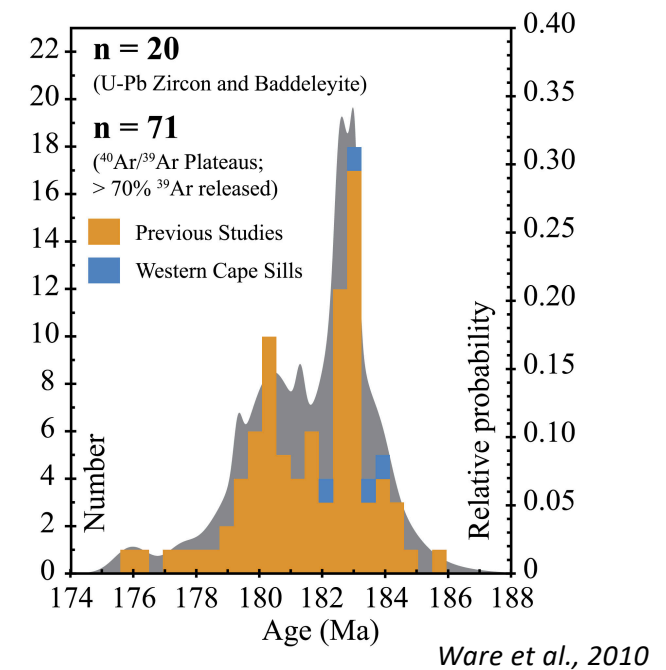
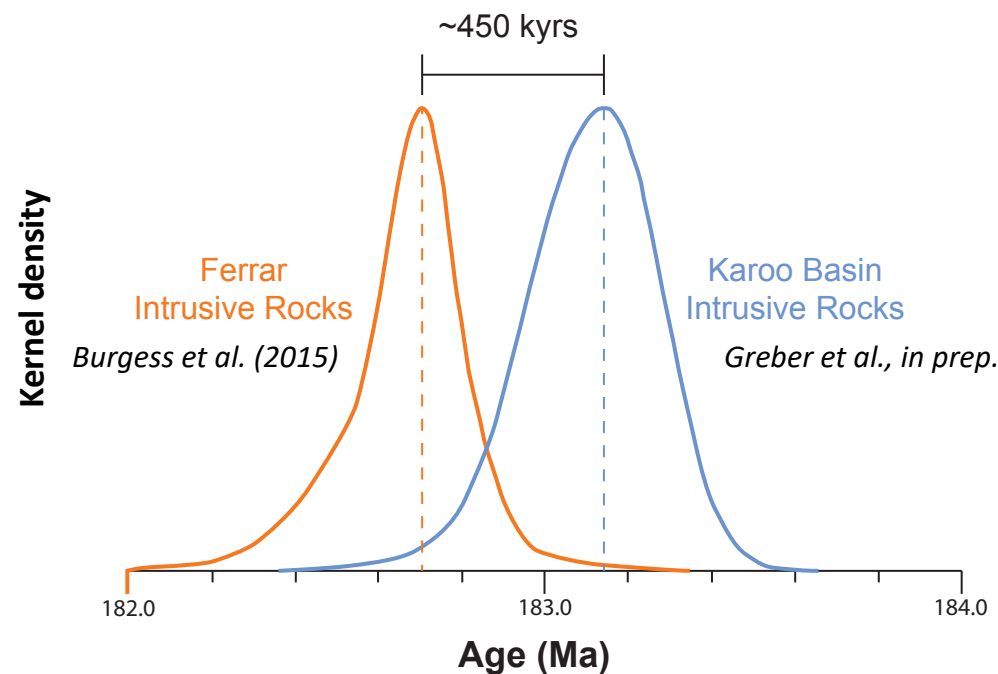


Dera et al., 2010

- 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

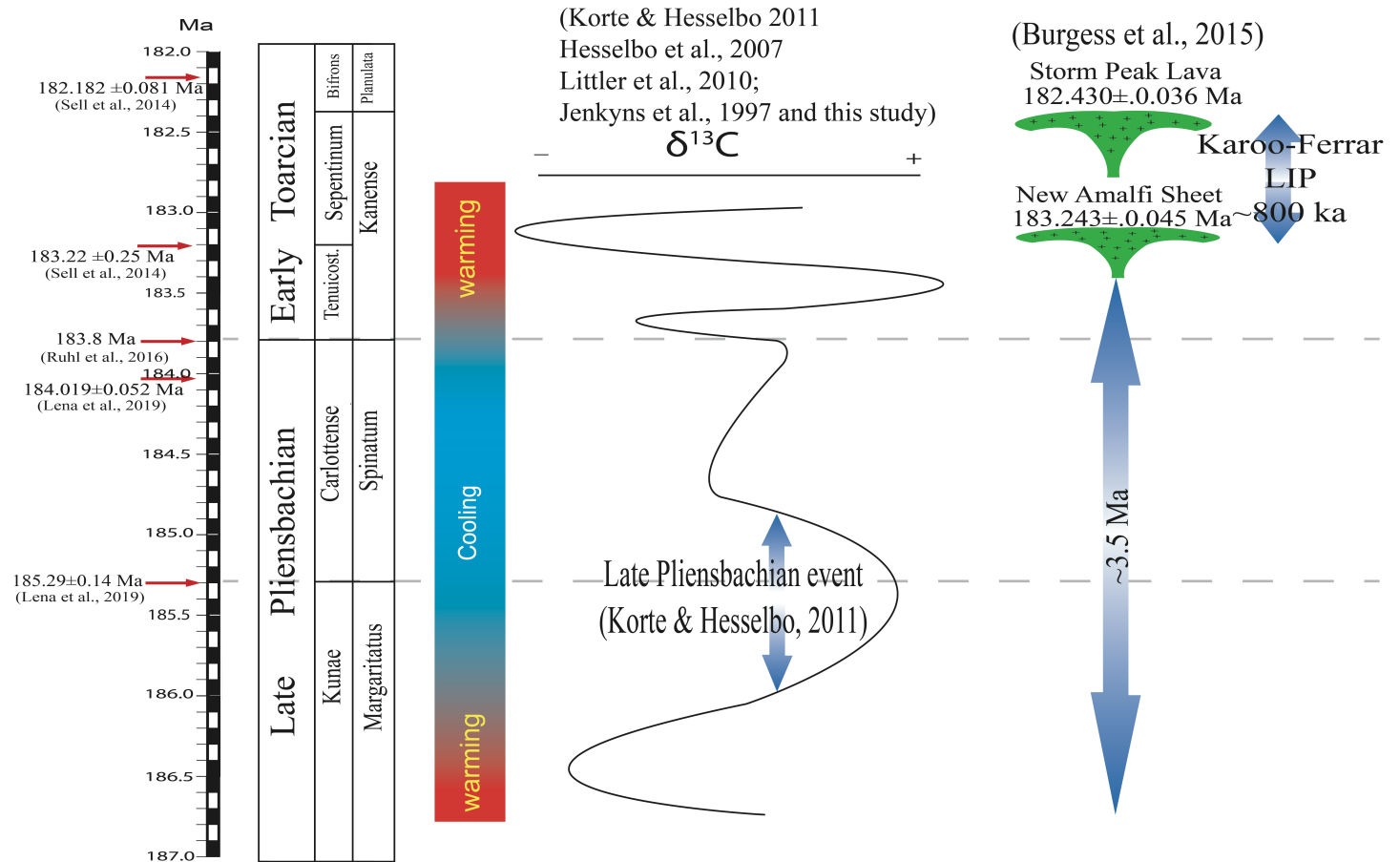
- Age of Karoo basin dyke-sill complex is ca. 183 ± 0.1 Ma and correlates with onset of Falciferum ammonite zone negative carbon isotope excursion (*Svensen et al., 2012; Corfu et al., 2016; Greber et al., manuscript in prep.*)
- Continued volcanic activity (Ferrar and beyond?) may be responsible for environmental perturbation
- No volcanic activity pre-183 Ma
- Previously published age scatter ($^{40}\text{Ar}/^{39}\text{Ar}$ 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 CO₂ 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