Paleolatitudinal distribution of lithologic indicators of climate in a paleogeographic framework

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1. Introduction and aims

Whether the latitudinal distribution of climate-sensitive lithologies is stable through greenhouse and icehouse regimes remains unclear. Previous studies suggest that the paleolatitudinal distribution of paleoclimatic indicators, including coals, evaporites, rocks and carbonates, has remained broadly similar since the Permian period, leading to the conclusion that atmospheric and oceanic circulation control their distribution rather than the latitudinal temperature gradient. In order to better understand the latitudinal distribution patterns of climate-sensitive lithologies and the associated climate change, we applied a global-scale compilation of paleo-depositional data, including coals, evaporites and glacial deposits, back to the Devonian period using novel data analysis approaches. We discuss how the distribution patterns change through time in response to plate motion, orography, evolution and greenhousehouse conditions.

2. Methods

(a) Present-day locations of peats from Ziegler et al. (2003) and Ziegler et al. (2003) using the SiZer method. High-density latitude ranges at confidence intervals of 50% (grey area) and 95% (black lines) of symmetric zonal patterns of coals (a), evaporites (b) and glacial deposits (c) from Boucot et al. (2013) and Ziegler et al. (2003). Probability density function (black lines) of symmetric zonal patterns of coals (d), evaporites (e) and glacial deposits (f) from Boucot et al. (2013) and Ziegler et al. (2003). Areas with at least one data point are indicated by red band and are indicated by blue band and solid arrows, respectively, at the top of the panel. (g) Global paleolatitudinal distribution of mountain ranges, shallow marine environments and ice sheets since the Devonian period calculated from the set of paleogeographic maps (Golonka et al. 2009; Cao et al. 2017). (h) Climatic temperature gradients since the Early Devonian derived from Boucot et al. (2013).

3. Paleolatitudinal distribution of lithologies

(a) Cumulative high-density probabilities are presented on the rightmost side with bold borders. (b) Atmospheric and oceanic circulation control their distribution rather than the latitudinal temperature gradient. We discuss how the distribution patterns change through time in response to plate motion, orography, evolution and greenhouse conditions.

4. Paleolatitudinal distribution patterns of lithologies and Contributors to them

(b) Probability density function (black lines) of symmetric zonal patterns of coals (a), evaporites (b) and glacial deposits (c) from Boucot et al. (2013) and Ziegler et al. (2005) using the SiZer method. High-density latitude ranges at confidence intervals of 50% (grey area) and 95% (light grey area) using the HMR method. The cumulative results for all times are presented on the right-hand side with bold borders.

5. Sensitivity tests on - 5.1 Continental area bias

(b) Atmospheric and oceanic circulation control their distribution rather than the latitudinal temperature gradient. We discuss how the distribution patterns change through time in response to plate motion, orography, evolution and greenhouse conditions.

6. Conclusions

1. Paleolatitudinal distributions of lithologies have changed through deep geological time, notably a pronounced poleward shift in the distribution of coals at the beginning of the Permian.

2. The distribution of evaporites indicates a clearly bimodal distribution over most of the past 400 Ma.

3. These climate indicators are sensitive to the correction of continental areas and do not show strong sensitivity to the reconstruction model.

4. There is no single factor that dominates the changing distributions from the Early Devonian to the present. Care should be taken when using the latitudinal distribution of these lithologies to constrain past global climate and the past positions of continents.

5. This study highlights that combining tectonic reconstructions with a comprehensive palaeolithologic database and novel data analysis approaches provide insights into the nature and causes of shifting climatic zones through deep time.

References