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Duration of the Early Toarcian, stratigraphic black holes and glacio-eustatism in a greenhouse world

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The late Pliensbachian–Early Toarcian was characterized by major environmental instabilities that affected the carbon cycle, sea-level, climate, the biota and numerous geochemical cycles. The temporal and causal relationships between these phenomena remain matters of debate. This debate is sustained by a controversy over the nature of orbital components expressed across the negative carbon isotope excursion (CIE), over the continuity of its record and changes in sedimentation rate in sections around the world. An extensive review of stratigraphic data recently led Ruebsam and Al-Husseini (2020) to propose a Lower Toarcian carbon isotope reference curve calibrated by ammonite zones and subzones, 405 kyr cycles, and replaced within a framework of transgressive-regressive (T-R) sequences. Four major discontinuities were identified globally and named 'stratigraphic black holes' (SBH). The present study refines the accuracy of this new integrated Time Scale and places in a common temporal framework environmental changes and the Karoo-Ferrar Large Igneous Province (K-F LIP). This timescale is tested for reference sections with a previously developed cyclostratigraphy and reveals a higher likelihood for a control by the 100 kyr over major steps of the negative CIE. The combination of 3rd order and 405 kyr-induced 4th order sea-level changes explains features of the CIE and the position of the 4 main SBH that relate with erosional unconformities, sequence boundaries and global cooling. The sea-level falls associated with the unconformities have amplitude of many tens of m that exceed by more than an order of magnitude falls associated with thermo-eustasy or aquifer-eustasy (Davies et al., 2020). We conclude that glacio-eustasy was a major controlling factor in the Toarcian "greenhouse" world and show that unconformities and highstands are consistent with the predictions of an Orbital Scale of glacio-eustasy (Matthews and Al-Husseini, 2010).

Keywords : early Toarcian, cyclostratigraphy, discontinuities, glacio-eustasy

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