Long-term lacustrine paleo-productivity and/or paleo-anoxia trends controlled by eccentricity cycles in the continental Autun Basin (France) at the Carboniferous/Permian boundary

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The organic-rich lacustrine beds of the Autun Basin (France) were deposited from the late Gzhelian (late Carboniferous) to the Sakmarian (early Permian), encompassing the Carboniferous-Permian boundary (∼299 Ma). Those deposits reach up to 1500 m thick, and correspond to a tropical, intra-mountainous late-orogenic basin infilling associated with the Variscan orogeny (Marteau, 1983; Schneider et al., 2006). Organic-rich and laminated facies are attributed to distal lacustrine environments which sometimes alternate with silty to sandy rich deltaic depositional environments (Mercuzot et al., 2019). The four successive formations (respectively the Igornay, Muse, Surmoulin and Millery fms) yield series of oil-shale beds (successively the Moloy, Igornay, Lally Muse, Surmoulin and Les Télots beds) (Marteau, 1983; Garel et al., 2017). The oil-shale beds are at least several m thick in the basin, except for the “Margenne” boghead bed which is only 0.3 m thick (Marteau, 1983; Garel et al., 2017). Recently, accurate U-Pb ages obtained on zircons from volcanic layers of the Autun Basin have placed the Carboniferous-Permian boundary within the Lally oil-shale beds (Pellenard et al., 2017).

In this work, we present a detailed study of the 364-m thick Chevrey 1 core, based on a Rock-Eval pyrolysis survey. The Chevrey 1 core encompasses the successive Igornay and Muse fms., including the Lally oil shale bed and the C/P boundary. TOC varies from 0.2 to 21 wt%, whereas HI values range from 22 to 421 mgHC/gTOC. The Lally oil-shale bed seems to correspond to a 2.5-m thick interval of maximum organic preservation between -145.02 m and -142.55 m, with TOC peaks reaching 12-21 wt%. However, the broad organic-rich interval seems much larger, with TOC around 6.1 wt% on average and HI values of 282 mgHC/gTOC on average between -157.3 m and -126.1 m. Moreover, a long-term progressive increase of TOC accumulation, highlighted by several organic pulses is obvious, starting at -282.4 m and pre-dating the Lally oil shale bed occurrence.

We thus evidence for the first time that the Lally oil shale bed corresponds to the short-lived apex
of a long-term lacustrine organic rich sequence of increasing paleo-productivity and/or paleo-anoxia that is ∼200m in thickness and therefore, is not only limited to a thin, (pluri)-meter-thick organic rich interval associated with short-lived anoxia and/or primary productivity pulse, as previously admitted. These findings rise the question of the paleoenvironmental mechanism(s) behind the occurrence of oil-shale intervals within the Autun Basin. Although further works are needed to fully understand those mechanisms, a preliminary cyclostratigraphy study using the Chevrey 1 TOC record suggests that the organic accumulation was likely controlled by climatic cycles in the Milankovitch frequency bands, and that the ∼200 m long-term organic trend may be linked to ~2 Myrs eccentricity.