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Cyclostratigraphy to improve the Paleozoic time scale – the good, the bad and the ugly

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High-resolution geologic time scales are crucial to apprehend Earth's history. Indeed, our understanding of processes shaping System Earth strongly depends on the knowledge of the succession of events, rates of changes and durations. Paleoclimate studies of all Eras demonstrate that Milankovitch cycles (obliquity, eccentricity and precession) induce significant variations in Earth's past climate on 10 000 to million years time scales. The use of these Milankovitch-driven climatic cycles, imprinted within the sedimentary record, represents a major development in chronostratigraphy. For large parts of the Cenozoic, the astronomical imprint in the sedimentary record could be correlated to the astronomical solution, resulting in astronomically-tuned time scales of unprecedented stratigraphic resolution. However, beyond the Cenozoic, different astronomical eccentricity solutions start to diverge, which means that tuning to an astronomical target becomes increasingly ambiguous. Still, cyclostratigraphy can contribute to the improvement of Mesozoic and Paleozoic time scales through the detection of eccentricity cycles in the sedimentary record. Indeed, the 405-kyr eccentricity cycle is extremely stable throughout the Phanerozoic. When identified through spectral analysis, this cycle can be used to build floating time scales.

During the last few years, numerous efforts have been made to improve the Devonian time scale through cyclostratigraphy. However, a cyclostratigraphic approach in the Paleozoic requires careful checking of the nature of the studied paleoclimatic proxy, assessing potential diagenetic alterations. Magnetic susceptibility, for example, is well-established as a paleoclimate proxy. However, most geological archives for the Devonian were remagnetized and thus require some precaution. Indeed, remagnetization doesn't always mean that the paleoclimatic signal is lost, but it should be carefully checked through characterisation of the magnetic signal with extra magnetic measurements and/or through comparison of the magnetic susceptibility signal with other paleoclimatic proxies.

Cyclical patterns in the verified proxy record can be identified through spectral analysis. These cycles can then be associated with the main Milankovitch periods. It is also important to check that not only ratios of classical Milankovitch periods are recorded but that the expected amplitude modulation of precession by 100- and 405-kyr eccentricity are also observed. Studying Milankovitch cycles in Paleozoic sedimentary successions not only allows for considerable improvements of the Devonian time scale, but also sheds new light on past diversification/extinction events. Indeed, several Paleozoic events seem associated with nodes of the long-term eccentricity (2.4 Myr) or obliquity (1.2 Myr) cycles. Furthermore, these long-term nodes can also be used in an event-stratigraphic context.