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The astronomical rhythm of Late-Devonian climate change: an integration of cyclostratigraphy and numerical climate modeling

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Rhythmical alternations between limestone and shales or marls characterize the famous Kowala section, Holy Cross Mountains, Poland. Two intervals of this section were studied for evidence of orbital cyclostratigraphy. The oldest interval spans the Frasnian - Famennian (Late Devonian) boundary, deposited under one of the hottest greenhouse climates of the Phanerozoic. The youngest interval encompasses the Devonian - Carboniferous (D-C) boundary, a pivotal moment in Earth's climatic history that saw a transition from greenhouse to icehouse. In both intervals, a clear eccentricity imprint can be distinguished. However, in this abstract, we will focus on the Famennian - Tournaisian (D-C) interval. This interval reveals eccentricity and precession-related lithological variations. Precession-related alternations clearly demonstrate grouping into 100-kyr bundles. The Famennian part of this interval is characterized by several distinctive anoxic black shales, including the Annulata, Dasberg and Hangenberg shales. Our high-resolution cyclostratigraphic framework indicates that those shales were deposited at 2.2 and 2.4 Myr intervals respectively. These durations strongly suggest a link between the long-period ($\sim$2.4 Myr) eccentricity cycle and the development of the Annulata, Dasberg and Hangenberg anoxic shales. It is assumed that these black shales form under transgressive conditions, when extremely high eccentricity promoted the collapse of small continental ice-sheets at the most austral latitudes of western Gondwana. Indeed, numerical GCM modeling (HadSM3) of the Late Devonian climate, suggests that rapid melting and ice sheet collapse is triggered during maximal austral summer insolation when eccentricity is high and the perihelion is reached in December. Under this particular astronomical configuration, the global climate is optimal and thus sea-levels are high. Moreover, the global hydrological cycle is enhanced, allowing for more intense rainfall and monsoonal regimes. These wet conditions, combined with accelerated pedogenesis at the increasingly vegetated landscapes of the Late Devonian, allow for an increase in the flux of organic matter and nutrients towards the ocean, triggering widespread eutrophication in shallow seas and the marine burial of massive quantities of organic carbon under oxygen-deprived conditions.