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## An attempt of time calibration of the Tournaisian and Viséan stages (Lower and Middle Mississippian) based on long duration orbitally forced sequences

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The Belgian Dinantian third-order sequence stratigraphy (HANCE et al. 2002), supported by robust biostratigraphic data, has been successfully extended to, and complemented, amended and confirmed in, sections outside Belgium (see references in POTY 2016). These sequences are glacio-eustatic (GILES 2009; POTY 2016) and their transgressive and regressive phases can be correlated respectively to ice melt and ice formation on the continent.

The three uppermost Viséan third-order cycles (sequences 9, 10A and 10B) were calibrated in the Windsor Group in Nova Scotia by GILES (2009) and assigned to eccentricity periods of 2.38 Ma (LASKAR et al. 2004) and to the identical large-amplitude period of the obliquity modulation (2.38 Myr according to BEAUFORT 1994). GILES (2009) recognized also the signals of the BEAUFORT (1994)'s additional obliquity modulation terms at 1.19 and 0.793 Ma. The duration of 2.38 Myr was also determined in Belgium (POTY et al. 2013) for the Hastarian (Lower Tournaisian) sequence 2 of HANCE et al. (2002), and partly for the sequences 1 and 3, by the count of the orbitally-forced precession cycles (about 17 and 20.2 kyr–18.6 kyr on a rough average duration, according to BERGER et al. 1992).

A comparison of the thicknesses of the calibrated sequences 1, 2, 3 and 9 in the Namur-Dinant Basin, with the mean thicknesses of the sequences 4A, 4B, 5 and 6, and their minor cycles, and additionally their (approximate) radiometric dating, suggests that their durations were also close to 2.38 Ma. On the other hand, the same rough comparison with the sequences 7 and 8 suggests that they could correspond respectively to the calculated obliquity modulation of 4.76 Ma and 0.79 Ma of BEAUFORT (1994).

The Tournaisian stage comprises the upper part of the sequence 1 (about 0.9 Ma according to POTY 2016) and the sequences 2 to 4B (the T/V Boundary is closed to the base of the sequence 5), that is 10.42 Ma. The Viséan stage comprises the sequences 5 to 10B, that is 17.45 Ma. From the International Stratigraphic Chart (COHEN et al. 2013, updated), the duration of the Tournaisian and Viséan stages are respectively 12.2 and 15.8 Ma, i.e., 1.78 Ma more for the Tournaisian and 1.65 Ma less for the Viséan, but the total duration for the two stages are very closed, respectively 27.87 Ma and 28 Ma. This suggests an uncertainty in establishing the T/V Boundary in sequence 5 – which usually is only developed in the deeper parts of the basins and not in the shallower ones – and therefore in the geochronological measurements.

Stages	FA	TOURNAISIAN					VISEAN						SER
Substages	Str	Hastarian			Ivorian		Moliniacian		Livian		Warnantian		P-A
Sequences	1	2	3	4A	4B	5	6	7	8	9	10A	10B	11
Sequence durations	2.38	2.38	2.38	2.38	2.38	2.38	2.38	4.76	0.79	2.38	2.38	2.38	
Stage durations	1.48	10.42 Ma					17.45 Ma						

Fig. 1: Time calibration of the Tournaisian and Viséan based on the durations of the third-order sequences.

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