An attempt of time calibration of the Lower Tournaisian (Hastarian Substage) based on orbitally forced sequences

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1. Introduction

The Hastarian Substage correspond to the lower division in Belgium and adjacent areas (CONIL et al. 1977,HANCE & POTY 2006). Third-order sequences are well marked in the Tournaisian and Viséan of the Belgian Namur-Dinant Basin and were the base for the revised sequence stratigraphy of the Mississippian of HANCE et al. (2002). Investigations in two sections in the Dinant vicinity displaying continuous well weathered sections - the railway cutting at Gendron-Celles and the Nutons quarry in Spontin – show that the lower Tournaisian part of the third-order sequences 1, the sequence 2 (Fig.1) and the lower part of the sequence 3, are divided in shorter sequences. Because of their relative regular distribution, their thickness, and the fact they are not grouped in bundles, these sequences are considered as due to only one orbital parameter corresponding to precession cycles.

2. Description and distribution of orbitally forced sequences

The sequences varry from alternations of shale and calcareous shale (mainly in the Pont d’Arcole Formation [Fm]) to alternations of calcshale and limestone (mainly in the Hastière Fm), and to limestone bed dominated (mainly in the upper part of the Landelies Fm). Their thickness varies from about 0.2 m to 1 m, and is strongly influenced both by the sediment production and by the compaction in the argillaceous levels and pression dissolution in the limestone levels. The distribution of their sedimentary nature follows the sedimentary evolution of the third-order sequences 1 to 3 described by HANCE et al. (2002). Truncations at the top of the sequences indicating emersion can occur during the low-stand (LST) and the falling-stage system tracts (FFST) of the third-order sequences. They are not marked during the transgressive (TST) and high-stand system tracts (HST), suggesting relatively low eustatic variations at the scale of these sequences.

The lower part of the Gendron-Celles section allows to study the orbitally-forced sequences in the Hastière Fm (HST and FSST of the third-order sequence 1, and LST of the sequence 2), almost from the base of the Tournaisian. The later is placed just above the 1.76 m-thick limestone bed marking the base of the Hastière Fm. That section is completed by the Spontin section which allows to study the sequences in the upper member (mbr) of the Hastière Fm (LST of the sequence 2), the Pont d’Arcole Fm (TST of the sequence 2), the Landelies Fm (HST and FSST of the sequence 2), and the Yvoir Fm (LST and TST of the sequence 3) in which is situated the base of the Ivorian Substage (base of Upper Tournaisian, base of *Polygnathus communis carina* Zone).

In the Gendron-Celles section, the 1.75 m-thick thin-bedded limestone unit situated just above the Devonian-Carboniferous boundary does not show any trace of rythmic deposits. Those ones develop above it and 31 sequences were counted in the rest of the lower mbr of the Hastière Fm. None was recognized in the 3.65 m-thick massive limestone of the middle mbr which marks the top of the sequence 1 (FSST). Both the Gendron-Celles and the Spontin sections show 15 sequences in the upper mbr corresponding to the LST of the sequence 2. In the Spontin section, 24 sequences compose the Pont d’Arcole Fm (TST 2), 28 the lower part of the Landelies Fm (HST 2), and 26 the upper part of the formation (FSST 2). 31 compose the lower part of the Yvoir Fm (LST and TST 3) until the Hastarian/Ivorian boundary (Lower/Upper Tournaisian boundary).

3. Attempt of calibration

The precession cycles vary through time and are usually considered as being not useful for a time calibration. But according to BERGER et al. (1989), the precession cycles for the Lower Tournaisian are about 17 and 20.2 Ka, and it is possible to consider 18.6 Ka as a rough average for their duration. On another hand, according to GILES (2009) who calibrated the three last third-order sequences of the Viséan to 2.4 Ma and considered that they could correspond to excentricity cycles, we consider that the Tournaisian ones also could last about 2.4 Ma. Therefore the 93 precession sequences recognized in the third-order sequence 2 could represent 1.73 Ma, suggesting that the erosion surfaces marking the sequence boundaries between sequence 1 and 2, and 2 and 3, could correspond to gaps as long as about 0.67 Ma if we consider a similar number of precession sequences in both sequences 1 and 3.

So, considering the duration of the 31 precession sequences in the Hastarian part of the third-order sequence 1, i.e. 0.577 Ma (not including the unknown time corresponding to the 1.75 m-thick unit at the base and the 3.65 m-thick unit at the top), + 0.67 Ma, + 1.73 Ma, + 0.67 Ma, + 31 sequences in the Hastarian part of the third-order sequence 3, i.e. 0.577 Ma, we obtain 4.224 Ma as a possible duration for the Hastarian. Note that, according to MENNING et al. (2001), the Hastarian lasted for about 6 Ma.

A refinement of that method and the extension of the recognition of orbitally forced sequences to the Ivorian Substage (Upper Tournaisian) possibly could contribute to a better definition of its length and of the one of the Tournaisian Stage.

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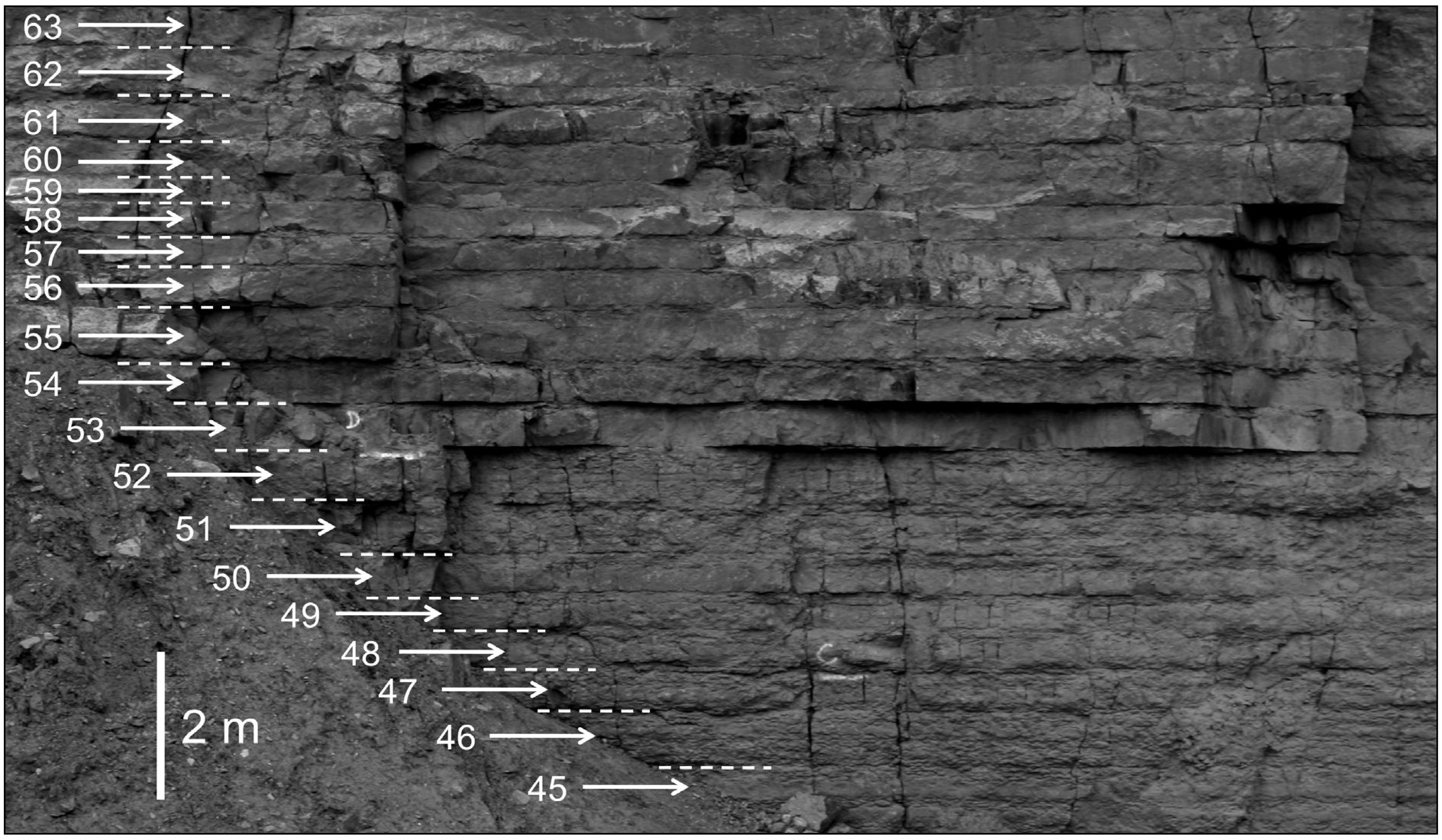

Fig. 1. Orbitally forced sequences 45 to 63 in the HST of the third-order sequence 2, lower part of the Landelies Fm, Hastarian; Nutons quarry, Spontin.