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## Rejuvenating the Paris Basin stratigraphy using “lost” drillings: the $\delta^{13}\text{C}_{\text{org}}$ calibration of Upper Thanetian to Lower Ypresian dinocyst events succession

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The Paris Basin represents an historical cradle of the Paleogene stratigraphy, where the notion of “Sparnacian” took shape in the Nineteenth century (Dollfus, 1880). Whereas Aubry et al. (2005) pointed on that the chronostratigraphic connotation of the “Sparnacian Stage”, sandwiched between the Thanetian and “Cuisian” marine sands, occurred to be controversial since its initial definition, modern studies of the Late Paleocene-Early Eocene interval revealed that the so-called “Sparnacian” deposits are not only often associated with the Paleocene-Eocene Thermal Maximum (PETM), but they are also diachronous across the Paris Basin. Hence the Sparnacian succession, represented by diverse and laterally variable, predominantly lagoonal and non-marine facies, is still insufficiently documented and needs an updated chronostratigraphic correlation with other Paleogene records worldwide. Although dinoflagellate cysts have been studied there since over 45 years (Châteauneuf & Gruas-Cavagnetto, 1968, 1978; Costa and Downie, 1976), no updated and revised dinoflagellate cysts distribution data are available yet, nor calibrated to more recent zonations (Powel et al., 1996) and to carbon isotope data.

Focusing on the high-resolution study of the “Sparnacian” deposits and their relationship with the PETM and its CIE events and processes, a number of new as well as some old drillings have been investigated in details palynologically and chemostratigraphically. The most expanded record of the Late Thanetian to Early Ypresian (*sensu* GTS 2012) here presented, including the Sparnacian facies, is preserved in the central part of the Paris Basin and has been deciphered thanks to the study of discrete samples of old drillings whose cores were lost: Le Tillet and Cuise-La-Motte.

In the Le Tillet core,  $\delta^{13}\text{C}_{\text{org}}$  values fluctuate between -23 and -26‰ PDB in the Châlons-sur-Vesles and Bracheux Fms and lower part of the Mortemer Fm; they exhibit three maxima, the most positive one occurring in the lowest second half of the Le Tillet Sand Mb, which is more shelly and was deposited in

shallower marine conditions. From this maximum at -23‰ PDB, an upward regressive trend is recorded until estuarine followed by terrestrial lignitic sands (Rivecourt Sand Mb) characterized also by upward decreasing  $\delta^{13}\text{C}_{\text{org}}$  values that reach -25.5 to -26.5‰ PDB.

According to our data, two successive NW European dinocyst zones of Thanetian age are recognized within the Châlons-sur-Vesles Fm (Le Tillet Sand Mb) from Le Tillet and Cuise La Motte cores: *Alisocysta margarita* and *Apectodinium hyperacanthum*. Dinocyst assemblages from the uppermost Thanetian (Bracheux Fm) may contain up to 30% of *Apectodinium* spp.

Above a terrestrial interval where the CIE onset is not clearly delineated in the top of Mortemer Fm or basal Soissonnais Fm from the Le Tillet core yet, the Muirancourt and Vauxbuin Mbs (Soissonnais Fm) reveal the most negative  $\delta^{13}\text{C}_{\text{org}}$  values (-27 to -28‰ PDB). The part of the CIE interval present in the lagoonal units of the Soissonnais Fm shows also an extremely pronounced *Apectodinium* acme (65-98% of dinocyst assemblage), while it is less pronounced in the more open marine units of the Dieppe-Hampshire Basin, for example in the Sotteville-sur-Mer, Cap d’Ailly and Siège-Madame drillings (Iakovleva, unpublished). The PETM assemblages are characterized by a significant number of longer specimens of *Apectodinium parvum*, which could represent an ecological onshore substitute of species *Apectodinium augustum* in the Paris and Dieppe-Hampshire Basins. The uppermost part of the Sparnacian facies included in the CIE interval reveals a number of unusual Wetzelielloids previously known from the *Apectodinium augustum* Zone interval in the Turgay Passage (Iakovleva, unpublished).

The lowermost unit (postdating the PETM) of the Mont Notre Dame Fm (Sinceny Mb) in the Paris Basin contains a very distinctive dinocyst assemblages, characterized by *Biconidinium longissimum* acme combined with still abundant *Apectodinium* (up to 50%). Unknown from adjacent Belgian, London or Dieppe-Hampshire Basins, the *Biconidinium longissimum* acme event has now been recognized in a number of sites; it may reflect a local and extremely specific environment in the Paris Basin, and appears to be a possible

stratigraphic equivalent of the North Sea Basin *Glaphyrocysta ordinata* or *Deflandrea oebisfeldensis* Zones (Early Ypresian *sensu* GTS 2012). As in the Sinceny drilling (Quesnel et al., 2011) this interval is characterized by very homogeneous  $\delta^{13}\text{C}_{\text{org}}$  values between -24 and -25‰ PDB in the Le Tillet core.

Overlying the Sinceny Mb in that core, the Laon Sand Mb exhibits more negative  $\delta^{13}\text{C}_{\text{org}}$  values calibrated with the occurrence of *Wetzeliella astra/lobisca*. The overlying Cuise Sand Fm can be attributed to the *W. meckelfeldensis* Zone, as shown previously also by Châteauneuf and Gruas-Cavagnetto (1978). It exhibits constant then decreasing  $\delta^{13}\text{C}_{\text{org}}$  values in the ‘Sables d’Aizy’, reaching a minimum at -27‰ PDB during an interval of 10 m, suggesting the record of the lower part of the EECO (or ETM2?) at the top of the ‘Sables d’Aizy’ and notably in the ‘Horizon de Pierrefonds’, just before a new upward increasing trend of the  $\delta^{13}\text{C}_{\text{org}}$  values in the ‘Argile de Laon’ which belongs to the *Dracodinium varielongitudinum* Zone interval.

Our new isotopic data obtained from the Le Tillet core’s discrete samples spanning 90 m of the Upper Thanetian to Lower Ypresian succession (including Sparnacian facies) delineate a curve comparable to the one compiled by Cramer et al. (2009) and reported in the GTS 2012. The data are then integrated to the other ones obtained with a higher resolution but lesser stratigraphic interval during the last years from the Paris and Belgian Basins, the Avesnois, and the eastern part of the Dieppe-Hampshire Basin; all of them enable to refine the high-resolution stratigraphic frame built from new drillings or exposures (Dupuis et al., 2011; Quesnel et al., 2011; Iakovleva et al., 2013; and unpublished data). Our study is the first attempt to make a first-order calibration between dinocyst and isotopic data from that interval (NP8 to NP12) in the shallow marine to lagoonal settings of the Paris and Dieppe-Hampshire Basins. It should be enlarged to similar depositional environments of the adjacent basins in order to provide high resolution bio- and chemo- stratigraphic frames, and then to correlate to the Arctic, North Sea and Atlantic records within deeper marine realms, the final objective being to decipher and compare in various and connected terrestrial to marine settings the impacts of the climatic events (among which a few hyperthermals) of the Early Paleogene, a critical episode of the Earth’s history.

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