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Disappearance of a carbonate ramp at the Lutetian - Bartonian boundary in the Pyrenees (Spain): evidences for the first glaciations of the Cenozoic?

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The early Cenozoic (Paleocene and Eocene) is known as the warmest period of the last 100 My, with little or no ice at the poles. This period shows an important transition between greenhouse climate to the present icehouse period. Geochemical and sedimentological data have shown that the first permanent ice cap was established on Antarctica at the Eocene/Oligocene boundary (∼34 Ma). However, some authors proposed that ephemeral ice sheets may have grown on Antarctica during the previously assumed ice-free late Cretaceous to middle Eocene world (Lear et al., 2000; Miller et al., 2005; Tripati et al, 2005) and the ages proposed for the first glaciation of the Cenozoic range from ∼100 to 33.8 Ma.

The sedimentation in the southern border of the Pyrenean foreland basin is characterized by the coexistence of carbonate and siliciclastic systems from the Paleocene to the Middle Eocene. In particular, the Guara ramp system, or Alveolina limestones, developed diachronously from the Lower Eocene onwards on the southward propagating foreland basin as the Pyrenean orogen developed. However, we remark the complete disappearance of the Guara ramp and of all carbonate systems in this basin from the beginning of the Bartonian (41.3 Ma) onwards. We propose to examine this disappearance as to be the consequence of a rapid cooling associated with the possible occurrence of ephemeral ice-sheets on Antarctica.

This assumption was tested through two approaches. First, we have studied the sedimentological record from the Lutetian carbonates to the Bartonian clastics in order to constrain the evolution of the amplitude of the high-frequency (Milankovitch scale, <1My) sea level variations. Our results show that the sea level variations during the Lutetian were of relatively low amplitude of +/-10m, whereas the sea level variations recorded during the Bartonian seem to approximate up to +/- 50 m of amplitude, suggesting a possible stronger influence of glacioeustasy.

We have also performed geochemical analyses on oyster shells to estimate the paleo-temperatures during this interval. Our record is not continuous but allows us to document a succession of 1) relatively warm temperatures during the Lutetian (∼30°C), 2) an increase of the temperatures during the early Bartonian (∼33°C) corresponding to the Middle Eocene Climatic Optimum (Bohaty and Zachos, 2003), followed by 3) a strong decrease during the upper Bartonian (∼25°C).

The sedimentological evidence, along with its record of isotopic and sea level variations all suggest a significant climate change at the transition from the Lutetian to the Bartonian. This climate shift could be a possible explanation for the definitive disappearance of the carbonate platform in the south Pyrenean foreland basin, and it adds to the growing evidence of ice on Antarctica prior to the Eocene-Oligocene boundary.