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Climate change at the Oligocene-Miocene boundary: new insights from an oyster δ^{18}O record from the Mediterranean margin

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A major feature of the long-term climate evolution during the Cenozoic is the transition from the "greenhouse" conditions of the late Early Eocene (∼50 million years ago) to our modern "icehouse" conditions with its much lower CO_2 levels and significant polar glaciation (Zachos et al., 2008). This transition occurred through a series of steps, amongst which the cooling at the Oligocene-Miocene boundary (known as Mi-1) that is associated to a large-scale expansion of Antarctic ice-sheets. Identification of cooling and polar ice-growth during the Oligocene and Miocene largely relies on δ^{18}O and Mg/Ca benthic foraminifera records from ODP/DSDP sites (e.g. Zachos et al., 2008; Mawbey and Lear, 2014; Beddow et al., 2016), and few records currently exist from shallow environments.

In this context the purpose of this study is to provide a new record of the evolution of shallow (<50m) seawater temperatures during the Oligocene and across the Oligocene-Miocene transition, from the oxygen isotope composition of bivalves collected within an open marine setting. Oyster δ^{18}O have been widely used for paleoclimatic studies, with the advantage of being easily screened using cathodoluminescence to avoid altered areas (Kirby 2000; Lartaud et al., 2010). While they have a sparser temporal and spatial distribution, they provide access to seasonal paleotemperature evolution that cannot be approached using foraminifera geochemical data from deep-sea cores. Over 200 oyster shells have been recovered from 26 different levels of the Carry-le-Rouet outcrop on the northern margin of the Liguro-Provençal Basin. This site presents numerous other bivalves in a well-defined chronostratigraphic framework with sediments deposited from the Chattian to the Burdigalian (Oudet et al., 2010; Demory et al., 2011). Bivalves recovered from environments of normal salinity only, based on floro-faunal associations, were carefully selected and screened under cathodoluminescence to select pristine calcite for isotopic analyses.

Following a decrease of about 1.5 ‰ for the Chattian to the Aquitanian, our record highlights an increase of about 2 ‰ in oyster δ^{18}O values throughout the Oligocene-Miocene boundary at Carry-le-Rouet, providing a new evidence for the record of cooling and/or increase of ocean δ^{18}O in low-latitude and proximal environments. Interestingly, maximum oyster δ^{18}O values coincide with the occurrence of abundant bryozoans in the sedimentary succession, which supports local cooling of seawater. High-resolution sampling within the biggest bivalve shells, perpendicularly to growth increments, revealed the existence of large seasonal variations of temperature and/or local seawater δ^{18}O, which is presented here for the first time.