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RESEARCH ARTICLE

Paleoceanography of the Late Cretaceous northwestern Tethys Ocean: Seasonal upwelling or steady thermocline?

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Abstract

In this study we attempted to assess whether seasonal upwelling or a steady thermocline persisted at the western margin of the Tethys Ocean during the late Turonian–early Coniacian interval. For this scope, we employed novel and published stable oxygen isotope ($\delta^{18}O$) data of various organisms (bivalves, bivalves, brachiopods, fish and belemnites). New seasonally resolved temperature estimates were based on the $\delta^{18}O$ record of sequentially sampled inoceramid (*Inoceramus* sp.) and rudist (*Hippurites resectus*) shells from the Scaglia Rossa and Gosau deposits of northern Italy and western Austria, respectively. Diagenetic screening was performed using reflected light, cathodoluminescence (CL), scanning electron microscopy (SEM) and stable isotope analysis. Originally preserved $\delta^{13}C$ and $\delta^{18}O$ values were used to characterize the lifestyle of the bivalves and detect vital effects that could have biased oxygen isotope-based temperature reconstructions. Inoceramid $\delta^{18}O$ values provide–for the first time–information on temperatures of Tethyan benthic waters, which were, on average, 14.4 ± 0.6 ˚C and fluctuated seasonally within a range of less than 2 ˚C. Such a thermal regime is in line with the temperatures postulated for late Turonian boreal water masses and support the existence of a cold water supply from the North Atlantic to the Tethyan bottom. Bottom cooling, however, did not affect the shallow water environment. In fact, the rudist-based temperature estimates for shallow water environment revealed a mean annual range of 11 ˚C, between 24 and 35 ˚C (assuming a seasonally constant $\delta 18O_w = 1.0$ ‰), which are among the warmest temperatures recorded over the entire Late Cretaceous. Our findings, thus, suggest a strong thermal and food web decoupling between the two environments. The absence of a seasonal vertical homogenization of different water bodies suggests the existence of a steady thermocline and, therefore, contrasts with the presence of an active coastal upwelling in the region as hypothesized by previous authors.

Introduction

Following the Aptian-early Turonian 'supergreenhouse' event (90–95 Ma) [1,2], the Late Cretaceous world experienced a time interval of significant global cooling [3–5]. Declining