Fantasia Alicia (2018) : Paleoenvironmental conditions during the Toarcian Oceanic Anoxic Event and the late Toarcian. Records from Switzerland, Chile and Argentina

Abstract

In this study, paleoenvironmental conditions during the Toarcian were evaluated in the marine and terrestrial realm from the northern and southern hemispheres. For this purpose, two topics were chosen: (i) the Early Toarcian Oceanic Anoxic Event (or T-OAE) and (ii) the lacustrine sediments, which were deposited in a volcanic-dominated setting during the late Toarcian.

The T-OAE was an episode of environmental perturbation marked by greenhouse conditions, oceanic anoxia and significant burial of organic carbon in globally distributed sites, accompanied by a carbon-cycle perturbation, which is expressed by a large negative carbon isotope excursion (CIE). This negative shift is likely resulted from the injection of isotopically light carbon into the atmosphere-ocean reservoirs during the emplacement of the Karoo-Ferrar Large Igneous Province. A variety of geochemical evidence show that global warming caused a general change in the hydrological cycle and increased the continental weathering rates, triggering ultimately the faunal, floral and environmental changes. Hitherto, most T-OAE studies were conducted on sedimentary successions deposited in epicontinental seas in NW Europe, which limits our understanding of this global event. In this study, different sites were chosen in distinct paleogeographic settings of the NW Tethys area along a transect: Jura, Sub-Briançonnais Basin and Lombardian Basin (Switzerland), as well as from the Andean Basin (Chile), to reconstruct, compare and confront the paleoenvironmental changes recorded in each hemisphere. The sections were correlated using the biostratigraphy, the occurrence of the negative CIE and the chemostratigraphy. In the studied sites, the expression of the T-OAE is contrasted confirming that local/regional mechanisms are superimposed on the global environmental perturbation. The sections from the Jura and the Sub-Briançonnais Basin have in common that they are characterized by organic-rich intervals, though more severe oxygen-deficient conditions were apparently present in the Jura as revealed by increasing redox-sensitive trace elements (Mo, V, Ni, Cu). The Lombardian Basin records well oxygenated conditions. Sediments from the Andean Basin do not record a classical expression of the T-OAE; organic-matter burial was not favoured, while dynamic conditions are recorded in a marl-limestone alternation. In the Swiss sites, high kaolinite content and detrital proxies (detrital index, Ti, Zr) together with high chemical index (CIA) values suggest a change towards a warmer and more humid climate coupled with an increase in the chemical weathering rates. High phosphorus (P) values during the T-OAE are mostly due to the presence of an authigenic phase and fish remains. The development of oxygen- depleted conditions likely promoted the release of organic-bound P back into the water column, thereby further sustaining the primary productivity in a positive feedback loop known from other OAEs. Low kaolinite content recorded in Chile, suggests that arid conditions prevailed during the T-OAE. The low rate of chemical weathering, together with

the possible closure of the connecting straits with the Panthalassa Ocean, likely limited the nutrient input into the Andean Basin. The comparison of the dataset from the Swiss transect and from the Chile indicates that the paleogeography and the climatic conditions seem to have modulated ultimately the potential to develop anoxic conditions.

To better understand the environmental conditions during the Toarcian in the continental realm, three lacustrine successions were studied from the Cañadón Asfalto Formation (Argentina). They are characterised by carbonate, organic-rich sediments, mudstone, sandstone, conglomerate, and tuffaceous material, which are interbedded with basaltic flows and dykes. These sediments were deposited in the Cañadón Asfalto Basin, which formed by extensional tectonics (pull-apart or rift basin) related to the breakup of Gondwana and was thus affected by volcanic activity. U-Pb analyses of a selection of volcanogenic deposits place the Cañadón Asfalto Formation in the late Toarcian (179.4 ±0.2 Ma; 180.3±0.1; 180.1±0.1). The new ages are indicative that the deposition of the Cañadón Asfalto Formation at least partly overlapped with the magmatism in southern Gondwana, which generated the Chon Aike and the Karoo-Ferrar large igneous provinces. Total organic carbon (TOC) content shows values up to 7 wt.% and hydrogen index (HI) and oxygen index (OI) values show typical values for terrestrial and lacustrine organic matter. The strong correlation between HI and $\delta^{13}C_{org}$ values suggests that the type and preservation of the organic matter determined the carbon-isotope signal and likely masked any change related to global exogenic variations. The isotopic composition of carbonates ($\delta^{13}C_{carb}$ and $\delta^{18}O_{carb}$) may indicate variable origins: freshwater carbonate, pedogenic carbonate, influence of hydrothermalism. Evidences for hydrothermal activity in the Cañadón Asfalto Basin are provided by the clay mineral assemblage dominated by corrensite, smectite, mica-vermiculite mixed-layers, and talc. Since Toarcian continental records are less well studied, this dataset provides important clues to better understand the development of organic-rich lacustrine successions in a volcanic context.