Geophysical Research Abstracts
Vol. 18, EGU2016-2499, 2016
EGU General Assembly 2016

Sedimentological, climatic and environmental changes during the Early Jurassic (Hettangian-Pliensbachian) on the northern Tethyan margin (Switzerland)

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The Early Jurassic interval witnessed different phases of paleoenvironmental change, starting with the end-Triassic mass extinction event, c. 201.4 Ma ago, which was marked by terrestrial ecosystem turnover, up to 50% loss in marine biodiversity and large turnovers in global geochemical cycles linked to the onset of Central Atlantic Magmatic Province volcanism (Raup et Sepkosky, 1982 ; Hesselbo et al., 2002 ; Deenen et al., 2010). This time interval saw equally a phase of major climate change near the Pliensbachian-Toarcian boundary, which was followed by the Early Toarcian oceanic anoxic episode (e.g., Suan et al., 2010). Previous studies mainly focused on these major and short-lived events, while the remaining intervals of the Early Jurassic received significantly less attention. Therefore, in this study, we examine the sedimentological, geochemical and environmental changes between these events on the northern Tethyan margin (Swiss Jura). With this purpose, a wide array of geochemical analyses (carbon isotope, Rock-Eval, phosphorus content, mineralogy, trace and major element content and clay analyses) and sedimentary observations has been performed on four sections and cores (Frick, Riniken, Pfaffnau and Kreuzlingen).

We observed two depositional systems: (1) the Schambelen Member (lower Hettangian) and the Frick Mb. (middle Upper Sinemurian), which are characterised by organic-rich shales intercalated by tempestites; and (2) the Beggingen Member (Upper Hettangian to Lower Sinemurian) and the Grünscholz, Breitenmatt and Rietheim Members (upper Upper Sinemurian to Pliensbachian), which are composed of carbonates marked by the presence of hiati, condensed beds, phosphate- and fossil-rich strata, and erosional features, which testify to a dynamic environment characterised by overall low sediment-accumulation rates.

The clay fraction, composed mainly of kaolinite, chlorite and illite, was controlled by various parameters. The rise of kaolinite in the Late Sinemurian was probably caused by a shallowing-up also shown by a decrease in phyllosilicates and an increase in the quartz content in the whole rock. The related sea-level change is probably linked to tectonically induced regional tilting. The lowest kaolinite contents are observed in the condensed sections where important remobilisation took place.

The isotope and rock-eval analyses reveal also important environmental changes:

(a) Two negative carbon isotope excursions measured on organic matter (CIEorg -2‰ are observed during the Early Hettangian accompanied by a change in organic matter composition, higher productivity (high hydrogen indices), anoxia (high trace element, pyrite and organic matter contents and presence of pyrite framboids; cf. also Schwab and Spangenberg, 2006) and higher weathering rates (CIA and clay mineralogy).

(b) The Early Sinemurian is characterised by a +4‰ CIEorg in this sections. Nevertheless, the globality and causes of this CIE remain to be determined.

(c) The Sinemurian-Pliensbachian boundary record a negative CIEorg (-3‰, followed by a positive CIE (+2‰ during the Early-Late Pliensbachian and a negative CIEorg (-1.5‰ during the Late Pliensbachian. These CIEs are also recorded in several other localities in carbonates, belemnites, wood and organic matter, and result likely from global events. These CIEs are linked to OM preservation and/or productivity changes and/or 13C-depleted carbon input(s).