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The Early Aptian C-cycle perturbation leading to Oceanic Anoxic Event (OAE) 1a

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Early Cretaceous marine sediments are important archives for studies of major climate perturbations and of response mechanisms of the biosphere to such events. This is evidenced by several high amplitude positive carbon isotope excursions, which are assumed to be the result of an increased burial of organic matter (OM) caused by a volcanically induced greenhouse climate. The Ontong-Java volcanism is thought to have indirectly caused the major C-isotope excursion of the Early Aptian. Its onset coincides with the OM-rich deposits of OAE1a (Menegatti et al., 1998) and is preceded by a prominent short-term negative "spike". The latter has been attributed to marine volcanism (Arthur et al., 1985; Arthur, 2000) or dissociation of methane gas hydrates (Jahren et al., 2001; Dickens, 2003).

In an attempt to elucidate the causes that led to the negative spike and ultimately to the OAE1a, we established a composite high-resolution inorganic and organic C- and O-isotope stratigraphy covering the Early Aptian to the onset of OAE1a for various pelagic and hemipelagic sections from the Tethys Ocean (Southern Alps, N-Italy (southern margin) and Swiss Prealps (northern margin)). Within the interval of the negative spike, additional C-isotope analyses of specific biomarkers of marine and terrestrial origin have been performed.

The expression of the Early Aptian events varies considerably among the investigated sections. Thicknesses are extremely variable due to frequent sedimentary hiatuses, a pattern that is well known from Barremian-Aptian successions and is interpreted to result from varying current intensities. The lithologies vary from limestones with frequent chert layers (e.g. Cismon and Pie del Dosso (S-Alps)) to more marly and silty limestones containing prominent marls and black shales (e.g. Pusiano and Capriolo (S-Alps), Roter Sattel (Swiss Prealps)).

The carbonate C-isotope values of the Early Aptian feature an increase in the earliest Aptian ranging from 1.6‰ to 3‰ whereas during the following negative excursion, the values drop to a minimum of 1‰ (Roter Sattel, Swiss Prealps). The organic C-isotope values range between -24‰ and -29‰ and show a positive trend during the Early Aptian before dropping to their minimum (-29‰) during the negative excursion. The negative spike is also recorded in the C-isotope values of both marine and terrestrial biomarkers, which show a decrease of up to 8‰ (Cismon (S-Alps)). Bulk $CaCO_3$ contents and nannoconid abundances show drastic drops at the base and within the negative spike interval.

The general trend towards more positive inorganic and organic C-isotope values in the earliest Early Aptian is thought to reflect volcanic outgassing leading to a beginning perturbation of the C-cycle due to the Ontong-Java volcanism. The following negative spike is related to a more important CO_2 pulse leading to ocean acidification (and causing the abrupt disappearance of nannoconids) and high pCO_2. The latter is indicated by the increased fractionation between organic C and carbonates observed both in the bulk OM and more clearly in terrestrial and marine biomarkers. It is possible that additional input of isotopically very negative C from the dissociation of methane gas hydrates further amplified the negative spike.

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