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Early Cretaceous climate change (Hauterivian - Early Aptian): Learning from the past to prevent modern reefs decline

Alexis Godet (1), Stéphane Bodin (2), Thierry Adatte (1), and Karl B. Föllmi (1)

(1) Institut de Géologie et Paléontologie, Quartier UNIL-Dorigny, Bâtiment Anthropole, 1015 Lausanne, Switzerland (Alexis.Godet@unil.ch), (2) Ruhr-Universität, Bochum, Institute for Geology, Mineralogy and Geophysics, Germany

In the last decades, the anthropogenic increase pCO2atm has been considered as one of the main contributors for the decline of modern coral reefs, and nearly 60% of these marine ecosystems are presently threatened (Bryant et al., 1998). Interactions between anthropogenic change and reef growth can, however, not be reduced to a single factor, and it is essential to look at the Earth's history to understand and counterbalance.
During the Early Cretaceous, enhanced pCO2atm may have been responsible, at least in part, for the demise of the carbonate platform along the northern margin of the Tethys through climatic feedback mechanisms. From the Hauterivian to the Early Aptian, increased rainfalls are documented from the clay-mineral association, by a change from a smectite-dominated (most of the Hauterivian), to a kaolinite-dominated assemblage (latest Hauterivian up to the early Late Barremian). This switch is dated to the Pseudothurmannia ohmi ammonozone in the Vocontian Trough of southeastern France (Angles section, Godet et al., 2008). It is immediately followed in time by major nutrient input, as is illustrated by the substantial increase in phosphorus accumulation rates (PAR), not only in this section, but also in the Ultrahelvetic area of Switzerland and in the Umbria-Marche basin of Italy (Bodin et al., 2006). On the other hand, the remainder of the Hauterivian is characterized by PAR mean values characteristic of mesotrophic conditions, whereas the Late Barremian witnesses the return to oligotrophic environments (lower PAR values).
Synchronously, these perturbations are mirrored on the platform by changes in the type of carbonate ecosystems. Indeed, a stronger continental runoff, and a subsequent input in the oceanic domain of nutrients (e.g., phosphorus) and clastic material modified marine palaeoenvironmental conditions and triggered changes in ecosystems. A unique archive of the Early Cretaceous carbonate platform is preserved in the Helvetic Alps, where the Kieselkalk Formation (Fm), is dated as Hauterivian; it consists of a quartz-bearing crinoidal limestone with bryozoans (Föllmi et al., 2007). The Lidernen Member (Mb; glauconitic and phosphatic interval) splits the Kieselkalk Fm into a lower and an upper part. Following on top of the Kieselkalk Fm, the Altmann Mb represents a second phase of slow-down or even cessation in the platform ecosystem activity, when the PAR values are the highest in basinal sections. This suggests that high trophic levels control the disappearance of healthy carbonate ecosystems; this hypothesis is testified by the rise of Urgonian-type carbonates during time of low nutrient input in the Late Barremian (Schrattenkalk Fm from the Gerhardtia sartousiana ammonozone upward). Interestingly, the same evolutionary pattern is recovered in the western Swiss Jura, where heterozoan association characterizes the Pierre Jaune de Neuchâtel (Hauterivian), whereas the Urgonien Blanc (Late Barremian – earliest Aptian), corresponds to photozoan carbonates deposited under oligotrophic conditions, as is suggested by the presence of rudists and corals.

References

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