Unlocking paleo-environmental information from the helvetic Alps: stratigraphy is the key!

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Shallow-water carbonate successions of early Cretaceous age are widespread in the external units of the western Carpathians, the Alps, southeastern France, the Pyrenees, and the Betic Cordillera. They embody the remains of an extensive shallow-water carbonate platform, which developed along the northern Tethyan margin along a distance of over 2500 km. The central European portion of the platform is presently locked up in the northern, Helvetic Alps, which extend from southeastern Germany and western Austria through Switzerland to eastern France. The structural architecture of the Helvetic nappe and thrust belt allows for the palinspastic reconstruction of proximal-distal transects across the former platform for distances surpassing 80 km, and the early Cretaceous platform sediments preserved therein provide, therefore, excellent insight into the spatial and temporal evolution of this platform. Furthermore, the presence of ammonites in marker horizons within the Helvetic succession is the key to excellent time control.

The growth and expansion of this important platform was not only influenced by changes in sea level, detrital influx, and surface-water temperature, but also by changes in trophic levels brought upon the platform by upwelling currents. We distinguish between phases of carbonate production dominated by oligotrophic photozoan communities (late Tithonian and Berriasian; late Barremian and earliest Aptian) and by mesotrophic and eventually colder water heterozoan communities (Valanginian to early Barremian, late early Aptian to late Aptian). Superimposed on this bimodal trend in platform evolution were long-lasting phases of platform demise for which we provide improved age control based on ammonite biostratigraphy (early Valanginian to early Hauterivian, late early to early late Hauterivian, latest Hauterivian to latest early Barremian, late early Aptian to early late Aptian and latest Aptian to early Albian). The initial phase of these episodes of platform demise corresponds in time to episodes of oceanic anoxic events (OAE's) and environmental change in general (Valanginian OAE, mid-Hauterivian event, latest Hauterivian Faraoni event, early Aptian OAE1a and late Aptian – early Albian OAE 1b).

In order to establish possible links between platform evolution and changes in the carbon cycle in the adjacent ocean, we compiled an early Cretaceous, ammonite-calibrated, $\delta^{13}C$ record from the Vocontian basin and surroundings. Based on a comparison between the temporal changes in this carbon-isotope record and coeval changes in the platform record, we suggest that the history of carbon fractionation along the northern Tethyan margin was not only influenced by changes in the oceanic carbon household such as in the rate of production and preservation of organic and carbonate carbon, and in the size of the oceanic dissolved inorganic carbon (DIC) reservoir, but also by the above-mentioned changes in the ecology and geometry of the adjacent carbonate platform. During phases of photozoan carbonate production, the platform was characterized by a confined geometry and may have operated as a sink of continental DIC and source of respired CO_2 to the atmosphere, thereby reducing the throughput of continental and input of platform DIC to the adjacent basin. Furthermore, it represented a source of aragonite to the adjacent basin and the exportation of this mineral and its eventual dissolution and inclusion in the oceanic DIC reservoir likely induced positive trends in the hemipelagic carbonate $\delta^{13}C$ record. During phases of heterozoan carbonate production, the platform possessed a ramp-like structure with improved communication to the adjacent basin, thereby facilitating the transfer of continental and platform-derived DIC into the basin. The heterozoan platform pushed the $\delta^{13}C$ system of the adjacent Vocontian basin towards more negative values. Platform drowning episodes implied highly reduced carbonate production, thereby facilitating the throughput of continental DIC. They are characterized by an initial increase in $\delta^{13}C$ values, followed by longer-term decrease in $\delta^{13}C$ values. Finally, protracted periods of heterozoan dominance and repeated drowning phases likely induced a general increase in the oceanic DIC reservoir, which lessened the sensitivity of the oceanic $\delta^{13}C$ system to short-term change. Such phases are recognized during the Valanginian-Barremian and Aptian.