Late Cretaceous organic matter rich sediments of onshore Morocco (Tarfaya Basin) and their relation to Oceanic Anoxic Events

Victoria F. Sachse*, Ralf Littke
a Institute of Geology and Geochemistry of Petroleum and Coal, EMR Group, RWTH Aachen University
* victoria.sachse@emr.rwth-aachen.de

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Introduction
Oceanic anoxic events (OAEs) have been widely discussed in literature and have been considered as key mechanism for organic carbon burial for specific time intervals (i.e. Locklair et al., 2011; Wagreich, 2012). The sediments are generally characterized by the occurrence of organic matter-rich pelagic sediments, such as black shales. Three factors were noted by Wagreich (2012) to qualify for an OAE: (1) widespread organic-rich strata, (2) correlation in time to qualify as a supra-regional single event and (3) accompanied by a significant carbon isotope excursion. In contrast to the global extents of the early Aptian OAE 1a and the Cenomanian-Turonian OAE 2, Arthur and Schlanger (1979) describe the occurrence of OAE 3 (Coniacian-Santonian) as regionally more restricted. The Tarfaya Basin in Morocco (Fig. 1) was highly affected by different phases of OAE, as the influence of OAE 2 is clearly stated in previous studies (i.e. Kühnt et al., 2002; Sachse et al., 2012), but the possible influence of OAE 3 on type, quality and quantity of organic matter is still poorly investigated. The main objective of the study was to determine conditions of deposition and preservation of organic matter based on a geochemical study on newly drilled cores. Indicators describing the depositional environment are discussed and a detailed overview on organic matter (OM) type, quantity, and quality is presented to improve the overall geochemical information available for the Tarfaya Basin. In addition, the relation to the OAE 3 can help to improve the knowledge about the extent of this event, its duration and quality with respect to source rock deposition (Sachse et al., 2014).

In addition, these organic geochemical parameters give indication for the petroleum potential of the investigated Late Cretaceous sediments.

Methods
Organic geochemical and petrological analyses have been carried out for the whole Late Cretaceous (Cenomanian-Turonian, Coniacian, Santonian and Early Campanian) sequence of the Tarfaya Basin, southern Morocco. Core samples of two wells (Tarfaya Sondage No. 1 and 2) and additional outcrop samples of Cenomanian age were analyzed in order to obtain more information about the depositional environment, the kind of organic matter and the hydrocarbon generation potential. To estimate the quantity, quality and maturity of organic matter, Corg measurements, Rock-Eval pyrolysis and vitrinite reflectance measurements were carried out. A modified van Krevelen diagram (HI/OI) and a cross-plot between HI and Tmax were used for kerogen classification. Thermal maturity of sedimentary organic matter was evaluated by means of pyrolysis parameters (Tmax, PI), microscopic color of liptinites in fluorescence light (qualitatively) and vitrinite reflectance. In a next step molecular organic geochemistry (GC, GC-MS) was performed on selected samples to specify the depositional environment of the organic matter. In addition sulphur content was measured giving further insight into the depositional environment and intensity of bacterial sulphate reduction. Corg vs TS ratios reflect the importance of sulphide reduction in the decomposition of organic matter, and thus give a qualitative indication of the redox status of the environment of deposition.

Results and Discussion
Highest Corg contents (Fig. 2A) can be correlated with times of or close after temperature maxima as for the Cenomanian/Turonian with a maximum at 93 Ma (Fig. 2B). Santonian and Campanian (85-75 Ma) also represent periods of high temperatures, though somewhat lower than during the Cenomanian and Turonian (Fig. 2B). The variations of Corg can therefore be explained by a stronger degradation of the organic matter due to increased oxygen availability and decreased temperatures. In addition, the higher amount of organic matter and its better preservation in samples except the Campanian ones, can be explained by the relative rise of the sea level (Haq et al., 1987, Fig. 2C) coupled with oxygen deficient conditions during the initial phase of deposition. As a result from restricted water circulation. Thus our data supports the assumption of various authors (i.e. Wagreich, 2012) that OAE 3 is distributed over a long time span and not a short term event as OAE 2. The negative feedback of organic carbon burial and preservation in contrast to Cenomanian/Turonian is thus related to decrease of global hothouse conditions during the Late Cretaceous and the better solubility of O2 as relatively high sea water temperatures occurred during the Late Cretaceous (Fig. 2B). As a consequence, changes in continent/ocean configuration as the opening of the Atlantic, climate, water circulation and sea level fluctuation (i.e. Beckmann et al., 2005, Fig. 2C) ultimately control the production and deposition of organic matter in the Atlantic Ocean.
Conclusions
A comparison of the investigated samples (outcrops, Sondage No.1 and Sondage No. 2) shows clearly that not all OAEs record similar depositional conditions as shown here for the temperature dependence of preservation. More regional controls (continental run off, salinity and water circulation) and models especially with respect to organic matter productivity and preservation should be considered. In any case Late Cretaceous hothouse conditions leading to low oxygen levels in deep water provided a situation favorable for organic matter preservation.

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References


