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Element mobilization and mineral (re-)precipitation in sedimentary rocks from Central Germany on a microscopic scale

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In this study we investigated original red bed sandstones and their bleached modifications of Buntsandstein (Lower Triassic) und Rotliegend (Upper Permian) deposits from Central Germany (SW-Thuringia, NE-Hessen) by mineralogical and geochemical means. The main focus was to examine the potential involvement of CO_2-bearing fluids and the effects of e.g. pH and Eh conditions in the bleaching-/alteration reactions, and to verify differences in element content in red bed and bleached rock types.
The medium to fine grained Buntsandstein sediments (subarkosic composition) are of fluvial origin, partially bleached with transitions from red (unbleached) to light colors (bleached). The Rotliegend rocks are medium grained fluvial sediments and partially bleached. Compared to Buntsandstein sediments the Rotliegend sandstones are enriched in volcanic lithoclasts and feldspars (feldspathic litharenite). Hence, initially the Rotliegend sediments have higher contents of potentially reactive mineral phases compared to the Buntsandstein rocks.
Commonly, bleaching of primary red bed sandstones is related to fluid-rock interactions. These bleaching phenomena can be caused by different mechanisms: (1) acidic fluids with reducing redox potential (Eh), (2) organic acids (e.g. near surface conditions, soil) and (3) the migration of hydrocarbons. Furthermore, bleaching and/or alteration of primary red bed facies deposits are often regarded as one important hint for CO_2-bearing fluid-rock interactions.

In this study the color of rocks is the most obvious implication of alteration/ bleaching, caused by iron reduction and thus the solution of hematite coatings. The involvement of CO_2-bearing fluids in bleaching reactions is indicated e.g. by the occurrence of later diagenetic carbonate minerals, the (partial) dissolution of feldspars and alteration phenomena of lithoclasts. Major and trace element analysis (methods: ICP-MS/-OES, XRF) reveals distinct differences between Buntsandstein and Rotliegend rocks. In reddish and bleached Buntsandstein sandstones the element concentrations are almost similar. In contrast, in Rotliegend rocks chemical differences between both phenotypes are well pronounced. Here, all elements are (strongly) depleted in bleached rocks, except for carbonate forming elements like Ca and Mn (additional verification by cathodoluminescence). Variations of Fe-Mn ratios in carbonates are indicative for changing pH and Eh conditions during/after bleaching reactions. Furthermore, there are strong variations in the concentrations of K, Al, Fe, the transitional trace elements (TTE) like Cr, Ni and Co, and also of the rare earth elements (REE). In addition to geochemical analysis samples of the two phenotypes (unbleached/bleached) were utilized for evolved gas analysis (DEGAS – directly coupled evolved gas analysis system). The analysis revealed significant differences of degassing behaviors between the two color zones (e.g. release of sulfur-, carbon-, and hydrogen species).
The study identified element mobilization linked to bleaching processes in Buntsandstein and Rotliegend sediments of Central Germany. These mobilizations show different intensities in Buntsandstein and Rotliegend rocks. They are based on the high rock maturity and corresponding low content of potentially reactive mineral phases in the Buntsandstein, contrary to Rotliegend sandstones, which contain high amounts of labile components.