Fe-Oxide/Hydroxide precipitates ("Eisenschwarten") in the Osning Sandstone (Teutoburger Wald, Germany)

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Introduction

Authigenic ferricretes ("Eisenschwarten") from the Lower Cretaceous Osning Sandstone have been mined for short periods of time as a minor Fe source in the 19th century. Their chemistry and time of formation in regards to diagenesis and tectonic activity was studied in the central part of the Teutoburger Wald (14 outcrops and former mining sites between Borgholzhausen and Oerlinghausen) and for comparison in the western part of the Teutoburger Wald near Brochterbeck (4 outcrops), see Fig. 1a.

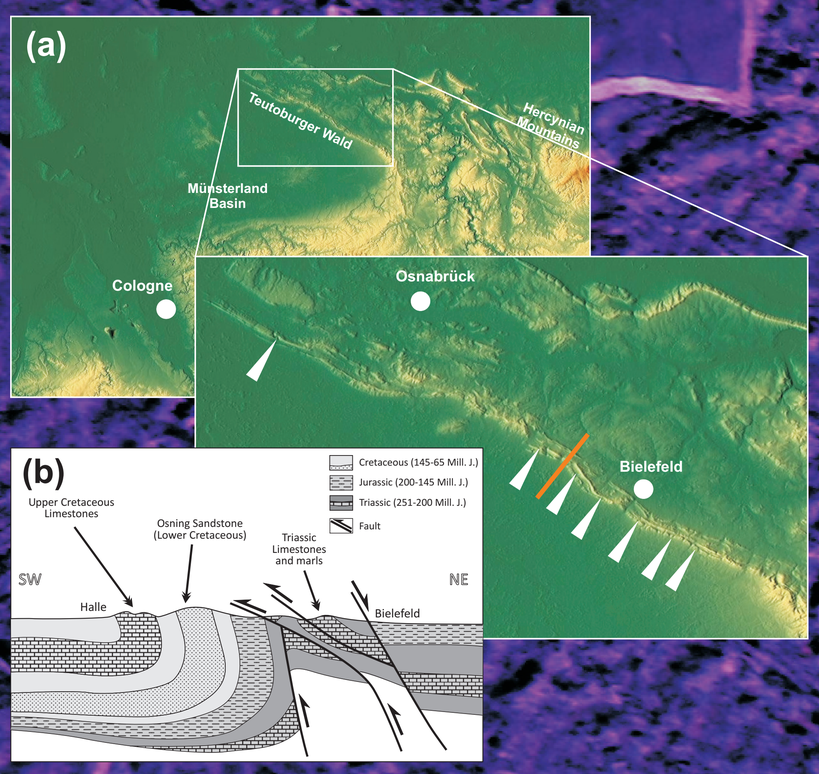

Fig. 1
(a): Location of the working area. White arrows mark the most important outcrops of Osning Sandstone, orange line marks the location of geological cross section depicted in (b).

Geological setting

The ridge of the Teutoburger Wald morphologically marks the NNW margin of the Münsterland Basin and is characterized by tilted to overturned sedimentary rocks of Mesozoic age, with intensity of deformation generally higher towards the southeast. Responsible for this deformation is the Osning Thrust, a complex fault system along which the Lower Saxony Basin has been thrust over the Rhenish Massif (Fig. 1b).

The Osning Sandstone is a Valanginian to Lower Albian coastal/shallow marine sandstone, usually fine-grained with occasional layers and lenses of conglomerate. In the working area, about 10 km around Bielefeld along the Teutoburger Wald, the Osning Sandstone reaches a thickness between 100 and 300 m.

Ferricretes (”Eisenschwarten”, Fig. 2) are an abundant phenomenon in the Osning Sandstone, but have before been widely regarded as very late structures, i.e. Quaternary or later weathering products.

Fig. 2
Typical appearance of ferricretes in the Osning sandstone. Note that ferricretes often mark the boundary between ochre, bright red and whitish areas. White (bleached) sandstone is distinctly softer than red or ochre sandstone; probably caused by dissolution of former cement.

References:

Baldschuhn, R. & Kockel, F. (1999): Das Osning-Lineament am Südrand des Niedersachsen-Beckens: Zeitschrift der Deutschen Geologischen Gesellschaft 150/4, 673-695.

Speetzen, E. (2010): Osning-Sandstein und Gault-Sandstein (Unterkreide) aus dem Teutoburger Wald und dem Eggegebirge und ihre Verwendung als Naturbausteine: Geologie und Paläontologie in Westfalen 77, 1-59.

Whole rock chemistry and Fe bearing phases

The Fe content of the Osning Sandstone is generally higher in the central Teutoburger Wald lying around 4-7.5 wt-% Fe_2O_3, compared to the Western Teutoburger Wald with usually around 1 wt-% Fe_2O_3 (this study and Speetzen, 2010). Accordingly, ferricretes are much more abundant in the central Teutoburger Wald.

Fe content of the ferricretes lies between 23 and 30 wt-%. The main Fe-bearing phase in the host rock and ferricretes is poorly crystallized Goethite, with minor amounts of Lepidocrocite. In places, Hematite has been found.

Timing of Fe precipitation

Fe oxide/-hydroxide precpitation has likely started already in Cretaceous times and the Fe-oxides/-hydroxides have been remobilized several times. At least three episodes of Fe precipitation have been identified from field observations.

- The first generation is most likely of diagenetic origin and occurs mostly parallel to bedding. Conglomerate layers are often impregnated with Fe and ferricretes penetrate the neighboring sandstone in irregular patterns roughly parallel to the conglomerates (Fig. 3).

Fig. 3
Conglomerate layer(center, parallel to pencil) with ferritic cement and ferricretes (dark brown) penetrating from the conglomerate into the neighboring sandstone.

- The second episode of Fe precipitation took place syntectonically during reverse faulting along the Osning Thrust system (starting in the Coniacian-Santonian, see Baldschuhn & Kockel, 1999) and subsequent normal faulting after crustal contraction has ceased. This is indicated by ferricretes precipitated along joints, reverse and normal faults and shear zones (Fig. 4).

Fig 4
Thin section micrograph of an Fe impregnated small scale normal fault with a displacement of ~ 1 cm. Note the cracked quartz grains close to the fault surface.

- The last episode of Fe mobility (probably Pleistocene-Holocene) is weakest and is mostly characterized by mm-thin ferricretes and intense development of Liesegang Rings, the latter of which often terminate at - and form an angle with - the impermeable ferricrete layers (Fig. 2).

Ferricretes and red coloration of the sandstone are much less abundant in the NW Teutoburger Wald, coinciding with much weaker deformation compared to the central Teutoburger Wald (tilted to 45° instead of overturned/strongly fractured), indicating that Late Cretaceous/Early Neogene deformation had a strong influence on mobility of Fe-bearing fluids within the Osning Sandstone.