F01

Are Cataclastic Shear Bands Fluid Barriers or Capillarity Conduits? Insight from the Analysis of Redox Fronts in Porous

T. Cavailhes (University of Montpellier II), R. Soliva* (University of Montpellier II), A. Benedicto (Areva), D. Loggia (University of Montpellier II), R.A. Schultz (University of Nevada at Reno) & C.A.J. Wibberley (Total)

SUMMARY

The effect of cataclastic derformation bands on fluid flow in a non saturated zones is still unclear. To discuss interaction between fluid flow and cataclastic bands in the vadose zone, we examine the spatial distribution of oxidation fronts around bands in the Turonian porous sandstones of Urchaux (SE France). Our study shows new field evidences that cataclastic bands behave as permeability barrier but also as capillarity conduits for wetweak fluid.

Present day mining exploration readdresses the old problem about the control of cataclastic deformation bands on fluid flow, which is still debated in petroleum research. Cataclastic deformation bands (CDB) are common structures in porous sandstones (Aydin 1978; Antonellini et al. 1994). These structures are tabular zones of finite width that have experienced grain rotation, crushing, cataclasis or cementation and they correspond to the localization of strain in porous rocks. Field and laboratory measurements exhibit evidence of porosity reduction in the CDB (ratio of ½ to ¼ of the host rock porosity) and that the CDB permeability is significantly reduced by one to six orders of magnitude relative to the host rock (Fossen & Bale 2007). In fluid saturated rocks, CDB seem to behave like transient barriers, whereas in non saturated rocks, their effect on fluid flow is not clear. In the vadose zone, a barrier effect was observed for paleofluids (Eichhubl *et al.* 2004) whereas laboratory tests suggest that CDB could be capillarity conduits (Sidga & *Wilson* 2003). In this work, we try to answer to the following question: Is there any field evidence for CDB capillarity suction? We examine the spatial distribution of oxidation fronts and CDB in the Turonian porous sandstones of Urchaux (*SE France)* to discuss interaction between fluid flow and CDB in the vadose zone.

Field work

Turonian porous sandstones of the Boncavaï quarry are poorly lithified sandstones with some clay beds and cross bedding stratification containing hundreds of normal displacement CDB. The outcrop is particularly notable by the presence of many oxidation fronts perturbed by the presence of the CDB (fig. 1). The sand reddening is attributed to iron oxidation and remobilization by fluid transfer.

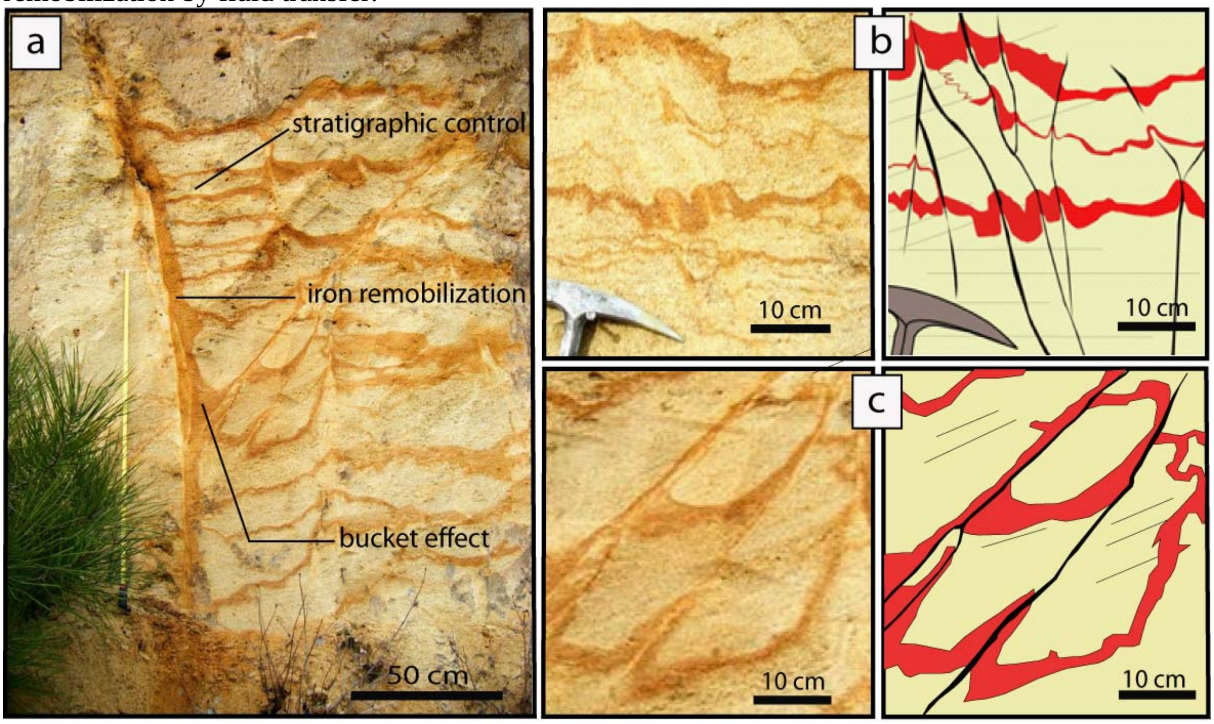

Figure 1 *Outcrop exposures in the massif d'Urchaux (SE, France). (a) Control of CDB and layering on the localization of iron oxides. (b and c) Field evidence of CDB capillarity effects.*

Iron oxides are systemically distributed in accordance with the presence of CDB. With respect to the lithology, the oxides are preferentially situated in coarse grain layers. They are often situated at the base of the beds and clay interfaces concentrate the very intense red colors corresponding to fronts stopped downward against the clays.

With respect to CDB, oxides are always localized along the bands and surface oxidations are always more important in the hanging wall of the structures than in their footwall. The intersection between two CBD leads to "bucket" oxide concentrations in the upper part, and unaltered shadow zones underneath the intersections of the bands (fig. 1a). In most cases, a thin zone of iron oxides is present along the band upper edge, outside the bucket geometry. There is no clear relationship between band thickness and significant color change on both sides. Oxidations located along tabular sandstone beds are systemically perturbed at the intersections with CDB, the combination of which produce a wave shape morphology (Fig. 1b). In this case, the red colored shape is observed along both sides of the band. Oxidation fronts moved upward the band with an amount which depends on band dip (Fig. 1c).

Discussion

The study shows that the sand reddening is attributed to iron oxidation and remobilization by oxidant fluid transfers in the vadose zone after the tectonic deformation. Sandstones are oxidized by gravity driven ground water saturated in atmospheric oxygen infiltrated from the surface. In a non water saturated zone, the main mechanism of oxidant solute transfer in high porosity sandstone seems to be advection (Taylor & Pollard 2000). We therefore make the hypothesis that the oxidation fronts underline preferential pathways for the ground water. We provide field evidences that CDB behave as permeability barrier, which is demonstrated by the oxide asymmetries relative to the band. In most cases, fluids seem to accumulate along CDB to flow downward in the sandstone as a result of gravity forces. These observations are consistent with previous works studying similar relations in the saturated zone (Fossen & Bale 2007).

Our study also shows evidence of a capillarity suction that seems inherent to non saturated zones as suggested by laboratory tests (Sidga & Wilson. 2003). This capillarity effect sends fluids upward along the bands against gravity (Fig. 2). The distance of fluid suction along the band is a function of CDB dip. The capillarity seems to attract fluids along the band although that dips of these structures are steep and the gravity component is therefore important along the band. For downward fluid migrations along the bands, gravity may be helped by capillarity suction to enhance fluid flow downward. As a conclusion, our study shows new field evidence that demonstrate the importance of capillarity conduits along CDB for wetweak fluid in a non saturated zone. This work is therefore important for the understanding of metal-bearing deposits.

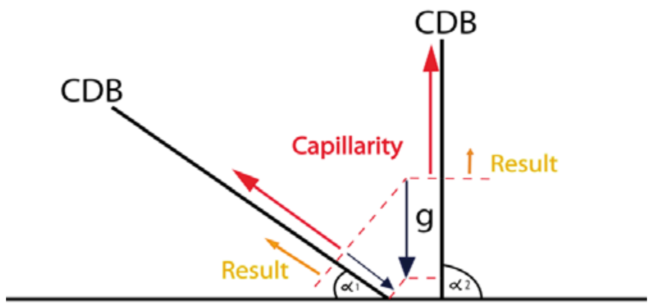

Figure 2 *Capillarity versus gravity. Resulting force is larger in the CDB for the low dipping case (α1).*

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