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**Fluid circulations and iron oxides associated on
cataclastic deformation Bands in porous sandstones,
Bassin du Sud-Est, Provence, France: new insights from
rare earth elements geochemistry**

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Present day mining exploration readdresses the old problem about the control of cataclastic deformation bands (CDBs) on fluid flow, which is still debated in petroleum research. CDBs are common structures in porous sandstones [1]. 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 CDBs (ratio of 1/2 to 1/4 of the host rock porosity) and that the CDBs permeability is significantly reduced by one to six orders of magnitude relative to the host rock [2].

In fluid saturated rocks, CDBs seem to behave like transient barriers, whereas in unsaturated rocks, their effect on fluid flow is not clear. In the vadose zone, a barrier effect was observed for paleofluids [3] whereas laboratory tests suggest that CDBs could be capillarity conduits [4]. In this work, we try to further understand and find field, mineralogical and geochemical evidences for CDBs behavior.

For that, we examine the spatial distribution of oxidation fronts and CDBs in the porous sandstones of Bedoin (SE France) to discuss interaction between fluid flow and CDBs in the vadose zone.

1. Location study

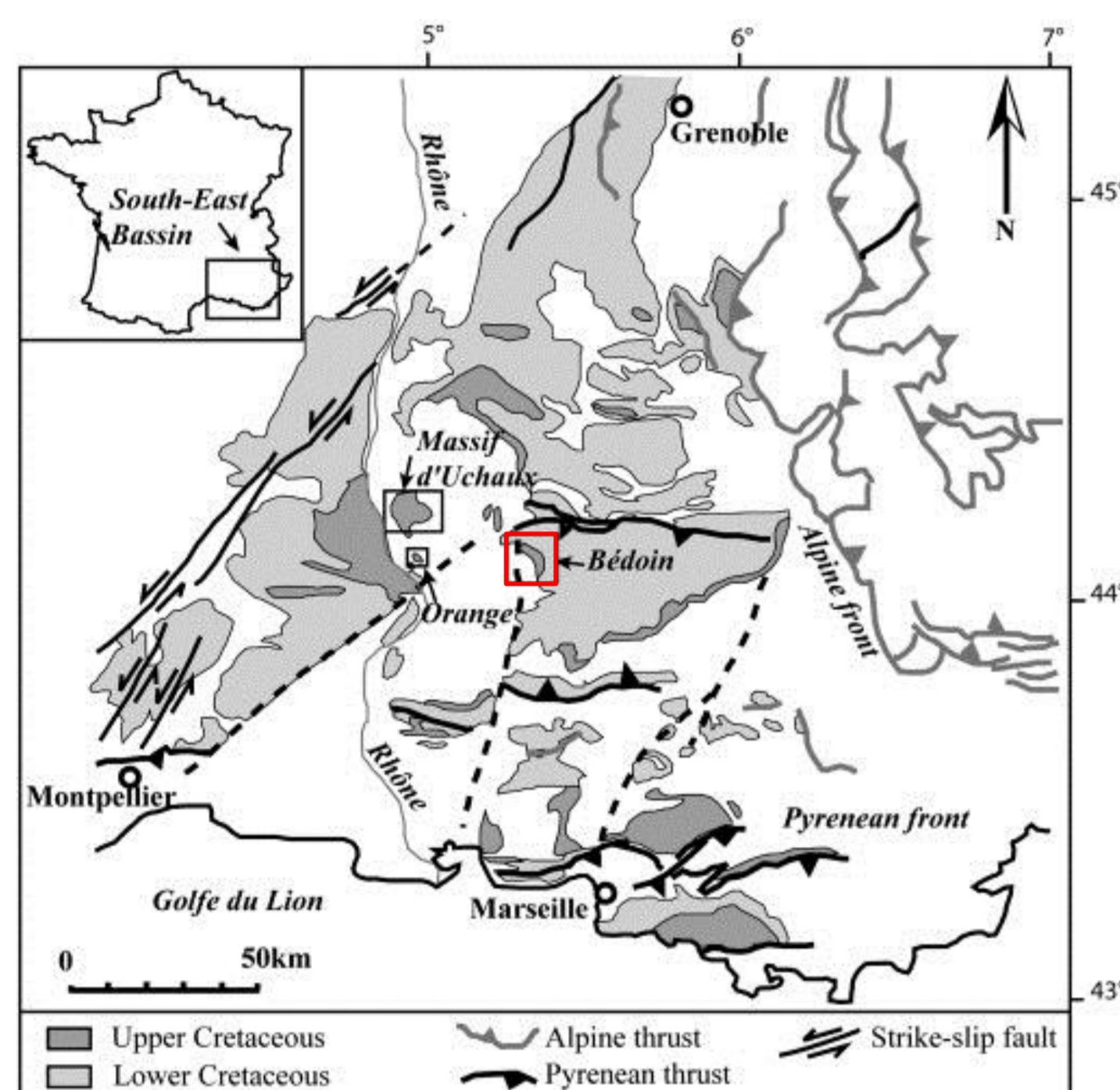


Fig. 1. Simplified geological and structural map of the study area in the Bassin du Sud-Est, Provence, Southeast France [5].

2. Site description



Fig. 2. Field view of large cataclastic deformation band (CDB) cluster with slip surfaces in sands from the Bedoin site. The total thickness of the deformed zone has an average of 70 cm [5].

3. Deformation Bands characterization

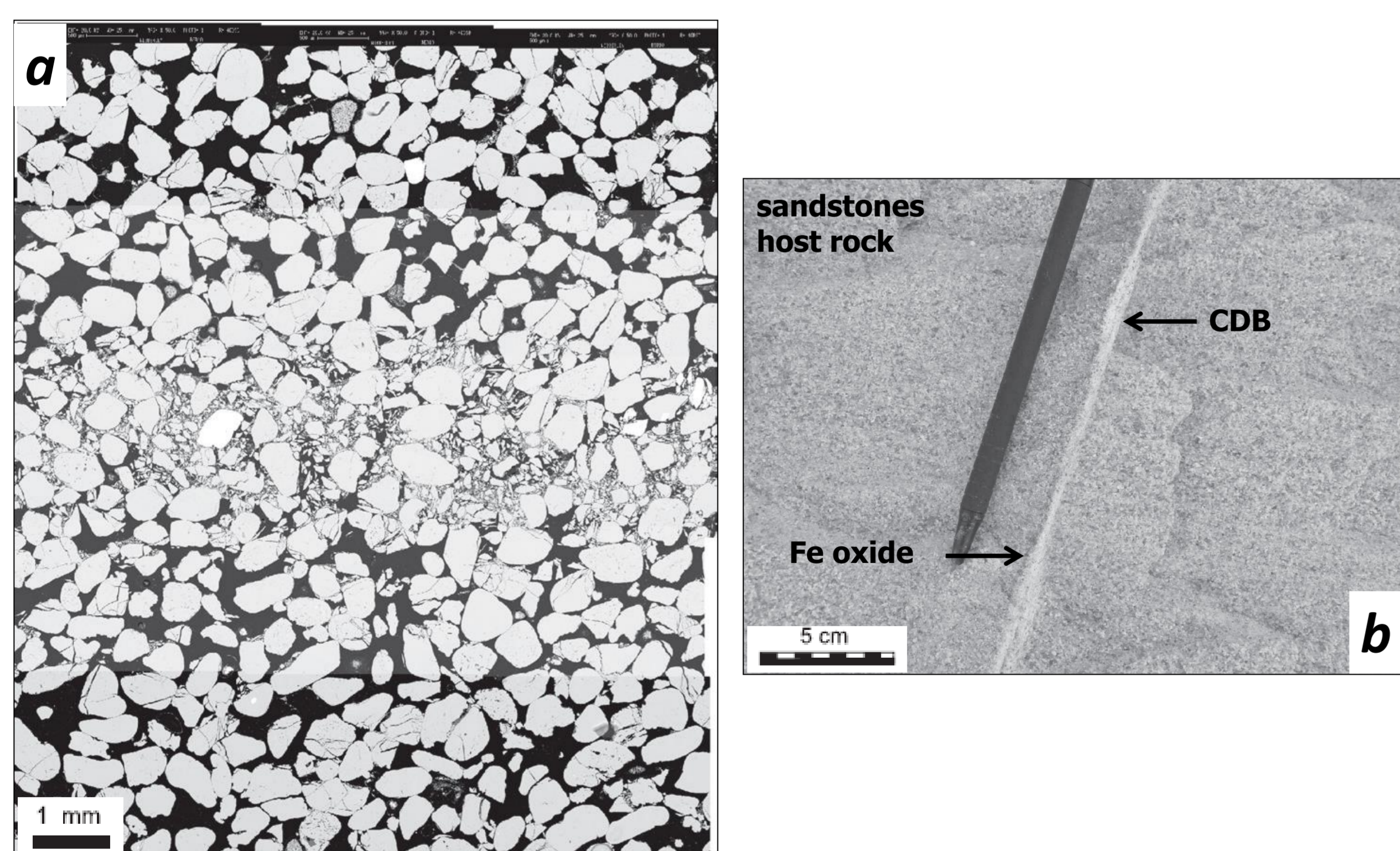


Fig. 3. a) Scanning electron microscope (SEM) photomontage of a single-strand CDB showing evidence for grain-size and pore-size reduction and two initiation zones of incipient strands with fractured grains, with host rock between both of them [5] SAILLET and WIBBERLEY, 2013). b) Single-strand normal-offset cataclastic deformation bands (CDBs) in sands [5].

4. Geochemical evidences of weathering

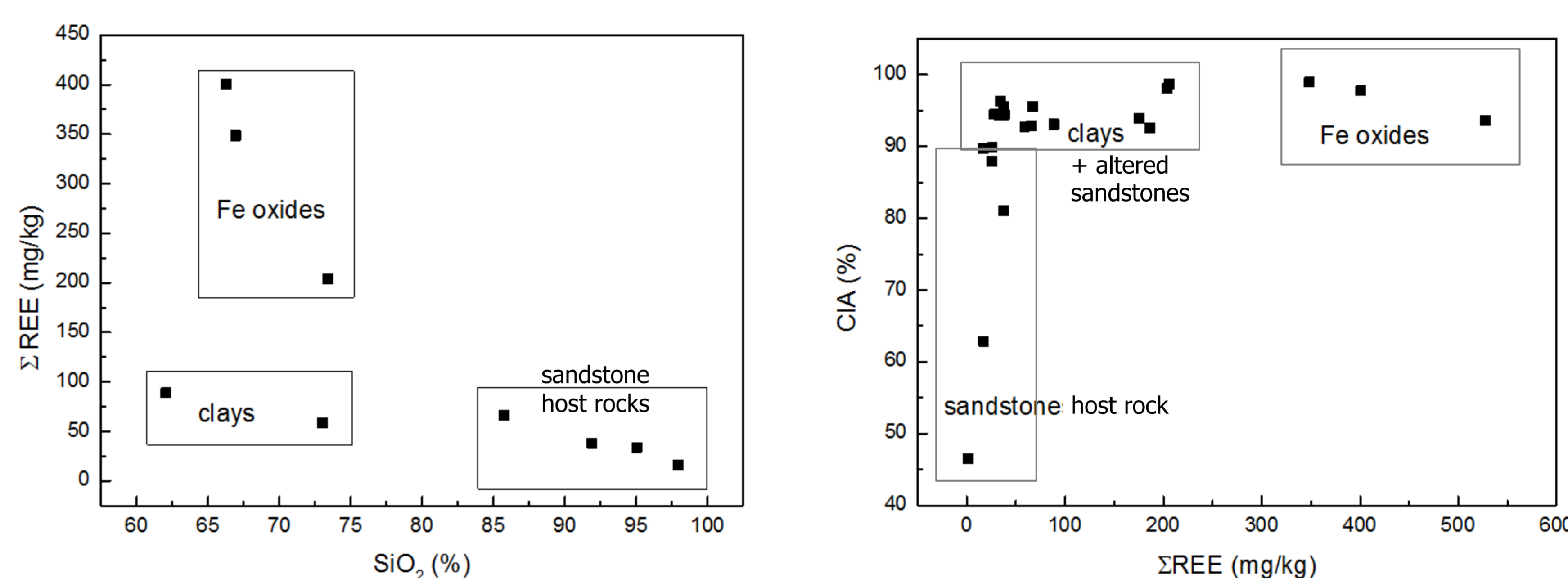


Fig. 4. ΣREE vs. SiO₂ and CIA vs. ΣREE. The Chemical Index of Alteration (CIA, [6]) higher than 90% indicates a strong alteration of the sample.

Sandstones host rocks are less altered, they have high SiO₂ and low REE contents. In contrast, the clays and altered sandstones are strongly altered and show low SiO₂ and REE contents. Fe oxides concentrate the REE and seem associated with weathered material.

5. Rare Earth Elements proxy of elemental mobility

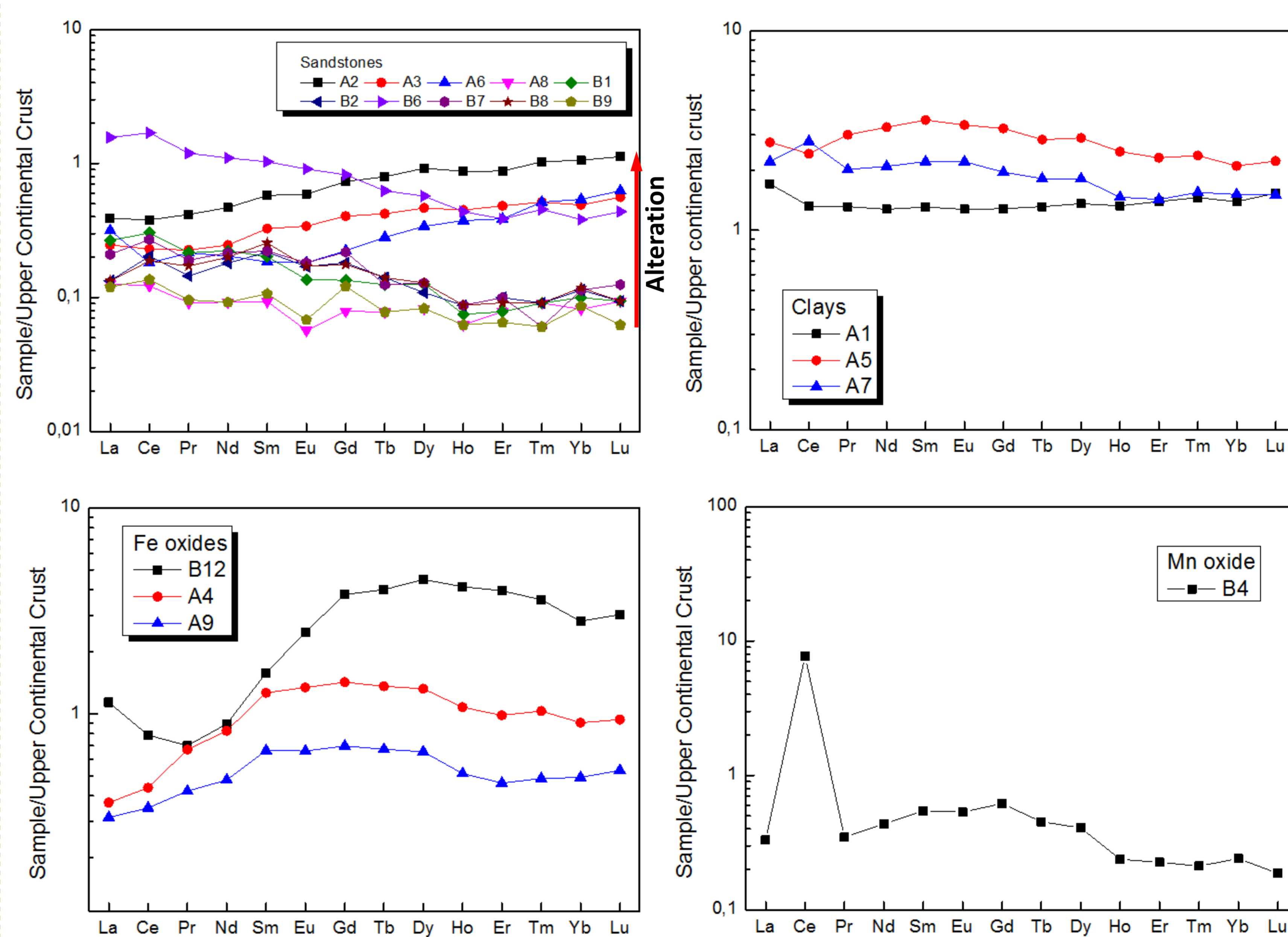


Fig. 5. REE patterns UCC normalized [7].

Fe and Mn oxides and clays show typical REE signatures.

Sandstone REE signatures evolve between host rock and altered sandstone: there is an heavy REE enrichment with the alteration.

Conclusion

The oxidation fronts underline preferential pathways for the ground water, localized along the CDBs (fig. 3). CDBs seem to constitute a trap where the oxides, contained in the fluid, are accumulated.

Fluid circulations have print specific rare earth element (REE) pattern in sandstone host rocks, clays and oxides (fig.5). They particularly print heavy REE enrichment patterns, the light REE remain in fluids and are carried downstream. Further analysis have to be performed on groundwater to verify this hypothesis.

BDs are both pipes and barriers to the fluid circulations along the fault zone.