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Depositional environments and diagenetic evolution of sandy carbonates and microbialites of the Central Morocco basin, examplified by the Tizra Formation (Mississippian)

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Introduction

Sandy carbonates and microbialites can form in completely protected, confined-semi-closed or open deep fore-reef environments under oxic to anoxic-bottom waters. In the northern part of the Carboniferous Central Morocco basin, mixed siliciclastic and carbonate sediments were studied from 7 stratigraphical profiles at the Tizra Formation (TF) for sedimentology, petrology, mineralogy, mineral and bulk rock chemistry. The depositional environment and the diagenetic evolution were reconstructed.

1 Results

The TF is exposed in the most important massif of the NE-SW trending Central Morocco basin which evolved to a foreland basin during Late Carboniferous. The TF is composed of five lithofacies: (1) channellized polygenic conglomerates at the base, overlain by (2) calcareous sandstones (cs) alternating with (3) argilites. (4) Bioclastic limestone (bl) varies from wackestone, packstone, and grainstone to rudstone and contain bioclasts essentially crinoids, brachiopods and foraminifera. They are cut by

calcite (cc) veinlets. (5) Massive microbialite (m) lenses occur within and at the top of the formation. Detrital minerals in cs are quartz, white mica, Fe-chlorite, zircon, apatite, monazite, rutile, and rarely, Zn- and Fe-sulfide inclusions in quartz, indicating a granitic source. Carbonate diagenesis is the major cementing process in all lithofacies, corroding the detrital quartz. Micrite is widely replaced by (micro-) sparite. A bimodal composition of cc is observed: (1) mainly low-Mg cc, (2) rarely, high Mg-cc (10-28 mol% $MgCO_3$), in recrytallised bioclasts, oolites and veins of cc. They are also rich in Fe (14 to 25 mol% $FeCO_3$) and can be classified as ankerites. Neoformed euhedral albite, quartz, dolomite (in crinoids), anhedral, high F bearing apatite and Ti-oxides contemporaneous to calcite, suggest *in-situ* Si, Na, Mg, Ti, P, F and Ca remobilisation. Rarely, barite was observed in bl. Framboidal pyrite formed during organic matter decay around calcite and quartz grains. Filamentous and cellular structured pyrite in m, might point to bacterial reduction. Shortly later influx of oxidizing fluids transformed framboidal pyrite partly into Fe-oxyhydroxides preserving the framboidal texture. As veinlets contain also Fe-oxyhydroxides and high Mg cc, they are attributed to the early diagenesis. The carbonate facies (bl and m) are characterized by a Ce and Eu negative, and a Gd positive anomaly, indicating that seawater was the major mineralizing fluid. The absence of a Ce negative anomaly in cs is due to the abundance of Ce rich apatite.

2 Conclusions

The Tizra Formation was deposited in alternating shallow and deep waters, in a confined to local semi-confined (due to organic matter decay) environment exposed to high and low energy currents. The TF is characterized by a low diagenetic grade. Primarily reducing conditions became oxic shortly after sulfidation. The general occurrence of low Mg cc indicates low water temperatures during deposition.

Keywords *: Carboniferous, Morocco, mixed siliciclastic-carbonate sediments, microbialites, depositional environments, rare-earth elements; low Mg calcite, microbial pyrite*