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Depositional Environments of Niamey Area Proterozoic Deposits (Western Niger)

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Abstract: ***This study uses a field approach based on the description of the different lithofacies of the Niamey area Proterozoic deposits, which are located on the southeastern edge of the West African Craton. The studied deposits represent a link between Taoudenni, Gourma and Volta basins. Three kinds of lithofacies have been distinguished. At the bottom, quartzitic sandstones with hummocky beds (Ny1 lithofacies), overlain by fine quartzites or glauconite sandstones, with oblique beds (Ny2 lithofacies). The presence of glauconite is an indicator of a shallow marine environment. These lowermost deposits are covered at the top by siliceous matrix-supported conglomerates with faceted and striated pebbles, considered as possible tillite (Ny3 lithofacies).***

Keywords: Neoproterozoic, Niamey area, Shallow marine environment, Glacial deposits

1. Introduction

The Proterozoic Eon is punctuated by several glacial events confined to two periods, one in the early Proterozoic (2.45-2.2 Ga) and the second in the late Proterozoic (1- 0.57 Ga) [6] [8], [27], [28]. Among these glaciations periods, two at least, the Sturtian (717–660 Ma) and the Marinoan (645–635 Ma), are regarded as global glaciation events, in agreement with the so-called Snowball Earth hypothesis [10], [11], [15], [20] [29]. This was suggested by the presence in most continents of the low-latitude glacial deposits (diamictites and tillites) usually overlain by the "cap" carbonates (dolostone and limestone) [9], [11], [12], [14], [21], [28].

Although the idea of a glacial sedimentation at low latitude during the late Proterozoic is nowadays accepted by the majority of the scientists.

Proterozoic deposits of the Niamey region, that are the subject of this study, are located in the western part of Niger, on the southeastern edge of the West African Craton (WAC) **(Fig. 1)**. They represent a link between the Proterozoic deposits of Taoudenni, and Volta basins **(Fig. 1)** [2]. Regarding these Proterozoic deposits of Niamey area few studies have been undertaken. The main objective of this study is to characterize the deposit environments of the Niamey area Proterozoic terrains.

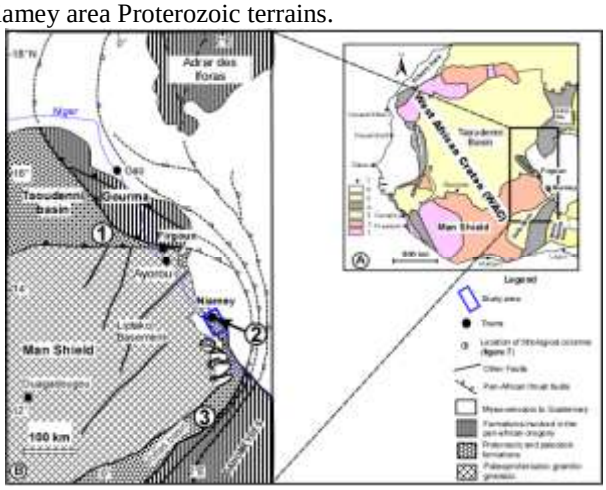

Figure 1: Location of the study area in the geological context of the West African Craton (from [2], modified)

2. Geological Context

In Niamey area, the Proterozoic deposits overlie unconformably the Paleoproterozoic terrains **(Fig. 3)** (Birimian Schists and Granites) [1], [3], [22], [23], [24] of the southeastern edge of the West African Craton. According to [5], the central part and eastern margins of the West African Craton are gently down-warped to form the Taoudenni and Volta basins **(Fig. 1)**. A very slow rate of subsidence was estimated at between 5–15 mm/1000 years and resulted in a basin infill of more than 8000 m (terrigenous siliciclastics at the base, followed by differentiated carbonate deposits) [5]. This infill suggests a large open sea to the ENE [5]. Two series have been distinguished in Taoudenni and Volta basins:

- The Supergroup 1, consisting essentially of sandstones, the sedimentation of which may have started in the Late Mesoproterozoic [4], [20], overlain in the Taoudenni basin by stromatolite-bearing limestones and dolomites;
- And the Supergroup 2 (Vendian-Cambrian in age) with the "Triad" of continental tillite barite-limestone-silexite at the base. The so-called "Triad" succession is classically regarded as a Neoproterozoic glacial marker, all over in West Africa [5], [7].

Supergroup 1 corresponds to the Lower Voltaian of Ghana and the Dapango-Bombouaka Group of north Togo. Lower Voltaian sediments could represent Transgression-Regression marine cycle upward the West African Craton. The Gourma Supergroup 1 formations, which rest unconformably on the Birimian basement, are overlain by fluviatile sandstones, which display transport directions toward the NE and E and which may be equivalent to Supergroup 2, although detailed stratigraphic correlations with the Volta Basin have not yet been established.

3. Methodological Approach

The present study used a field approach, which consists of making lithostratigraphic columns of the Niamey area Proterozoic terrains. The lithostratigraphic columns allow

establishing the vertical succession of the different lithofacies. In order to precise the Proterozoic rocks fabric and their mineralogic composition, thin sections of samples have been made and analysed.

4. Results and Discussion

4.1. Lithostratigraphic column

In Niamey area, a synthetic column of about 20 m thick has been made **(Fig. 2).** Three types of lithofacies have been distinguished. At the bottom, quartzitic sandstones with hummocky beds **(Ny1 lithofacies),** overlain by fine quartzites, glauconite sandstones, with oblique beds **(Ny2 lithofacies)** and covered at the top by siliceous matrix-supported conglomerates with faceted pebbles which are sometimes striated **(Ny3 lithofacies).**

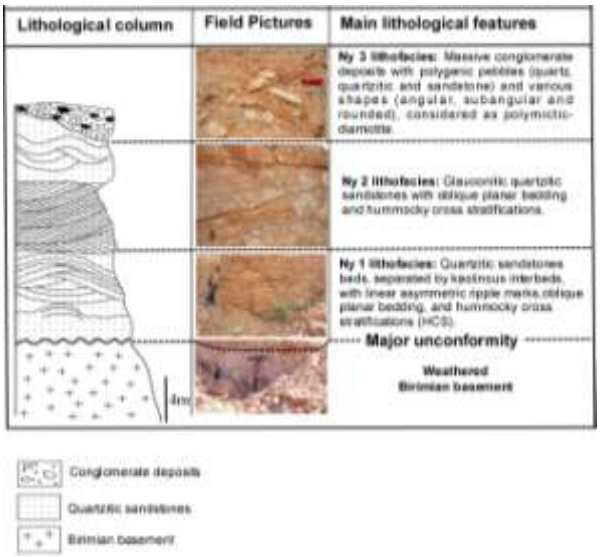

Figure 2: Synthetic lithostratigraphic column of Niamey area. Ny1 lithofacies: Quartzitic sandstones with hummocky beds; Ny2 lithofacies: Fine quartzites, glauconite sandstones, with oblique beds; Ny3 lithofacies: siliceous matrix-supported conglomerates with faceted pebbles which are sometimes striated

Ny1 lithofacies

This lithofacies is composed of medium to fine-grained quartzitic sandstones, which overlay the Birimian basement of the Liptako with a major unconformity **(Fig. 3).** These basal sandstones are deposited in the form of bed of metric to decimetric thickness with hummocky beddings **(Fig. 4).** The sandstone beds are separated by kaolinite interbeds having a centimetric thickness **(Fig. 5).** The presence of hummocky beddings is an indicator of a shallow marine environment.

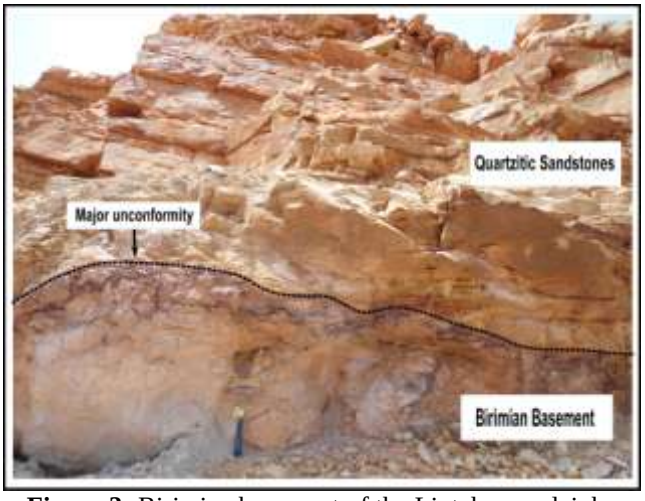

Figure 3: Birimian basement of the Liptako overlainby quartzitic sandstones, with a major unconformity (Ny1 lithofacies, Niamey area).

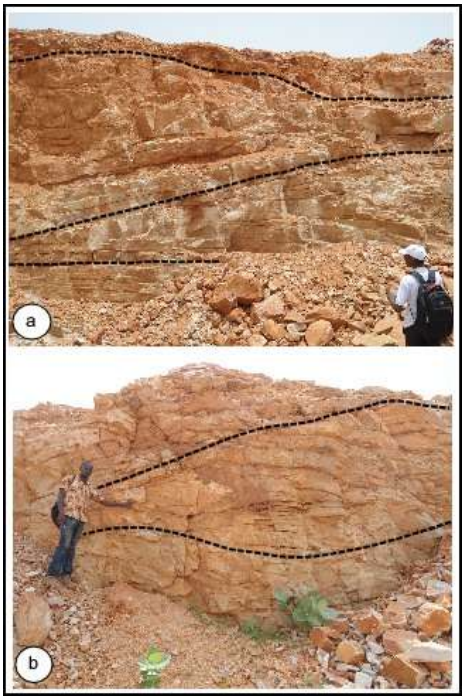

Figure 4 (a and b): Hummocky beddings in quartzitic sandstones (Ny1 lithofacies, Niamey area).

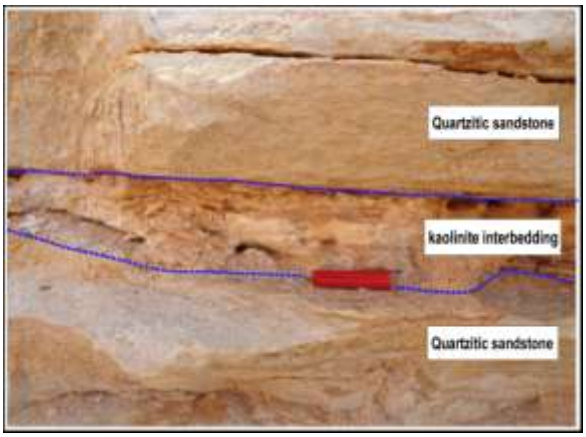

Figure 5: Quartzitic sandstone separated by kaolinite interbedding of about 3-10 cm thickness (Ny1 lithofacies, Niamey area)

Ny2 lithofacies

This lithofacies includes fine-grained quartzitic, glauconite sandstones **(Fig. 7)** with relatively blunted quartz grains. The sedimentary structures observed are: linear asymmetric ripple marks **(Fig. 6)** with a transport direction from SW to NE, planar cross bedding associated to hummocky cross stratification **(Fig. 4)**. The characteristic feature of these linear asymmetric ripple marks is the great length and continuity of the crests. These crests are rounded or flat and bifurcations are common. The linear asymmetric ripples occur widely on point bars. The presence of glauconite **(Fig. 6)** is an indicator of a shallow marine environment.

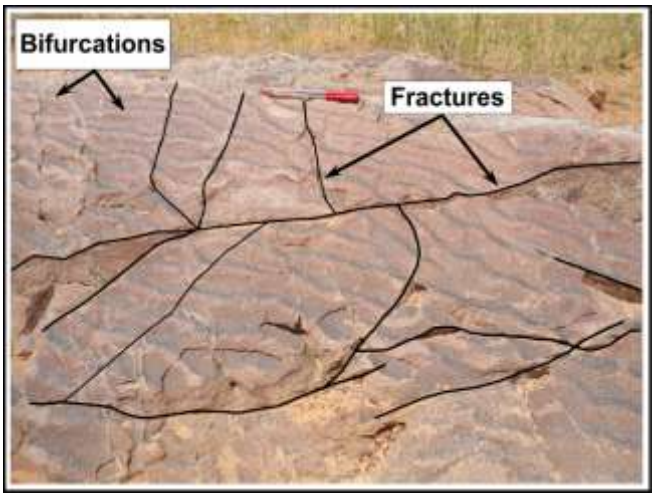

Figure 6: Linear asymmetric ripple marks with rounded or flat crests and bifurcations (Ny2 lithofacies, Niamey area)

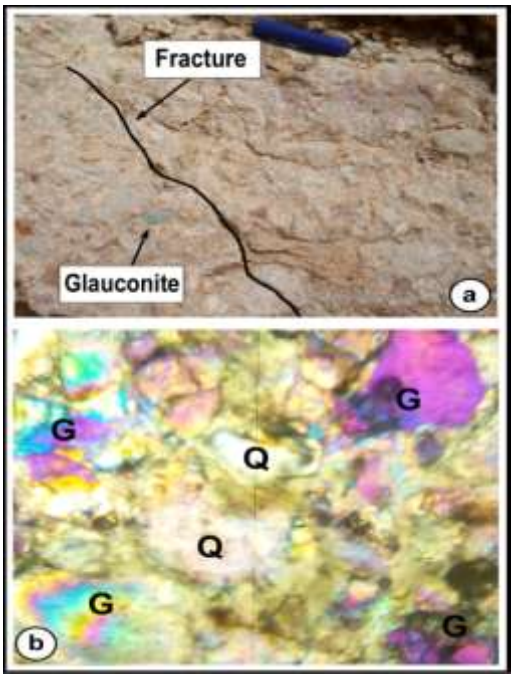

Figure 7: Quartzitic, glauconite sandstones (Ny2 lithofacies, Niamey area). **a:** Field picture; **b:** Thin section picture (Q= quartz; G= glauconite).

Ny3 lithofacies

It is composed of conglomeratic deposits **(Fig. 8)** that lie unconformably on quartzitic sandstones. They crop out with a thickness of about 4 to 10 m. The conglomerates are more or less brecciated. They are matrix-supported with centimetric to decimetric fragments of rocks of variable composition (polymictic-diamictite) as granite, quartz, quartzite, flint of various sizes and forms (angular, subangular, and rounded). Among them, quartzite fragments are the most abundant. All these pebbles have undergone a very short transport and are deposited in bulk with an abundant matrix of coarse sandstones, which encloses finer levels. Many kinds of minor fractures affected pebbles. Some are asymmetrically arranged with respect to the main fracture and referred as horsetail fractures **(Fig. 8.b)**. The observed pebbles have parallel tabular faces and a pentagonal shape (faceted pebbles (**Figs. 8.a and 8.c)**, which are sometimes striated (**Fig. 9)**). Placed on their large face, these pebbles show a flat iron shape. These pebbles often have hollows, resulting in a kidney shape **(Fig. 8.b)**. Therefore, these polymictic rock fragments, deposited in a floating ice context, may be considered as possible tillites, which are glacial deposits.

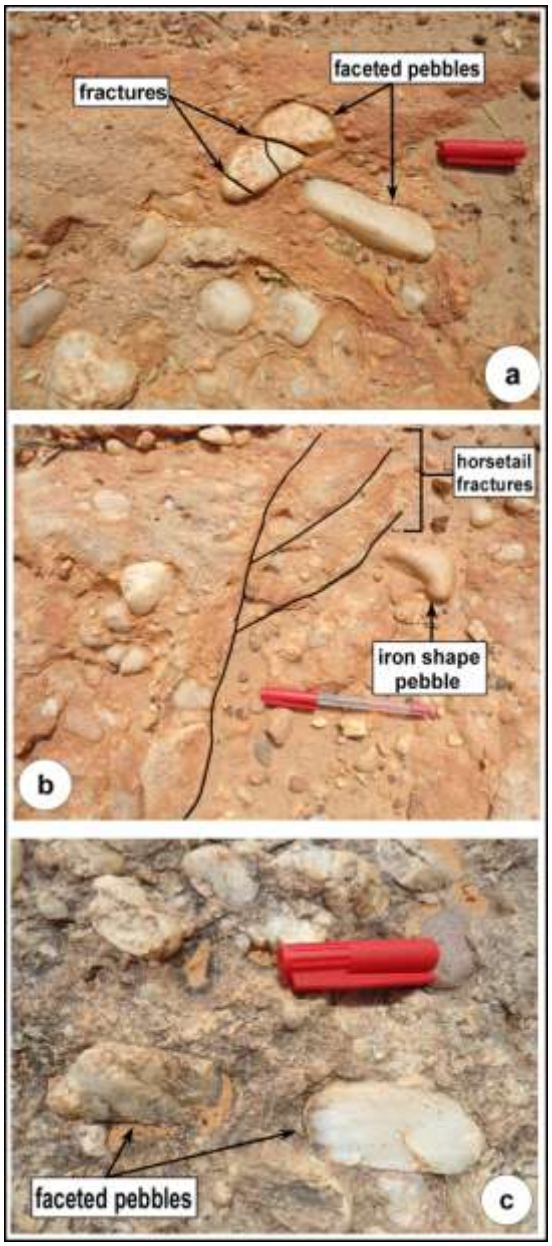

Figure 8 (a, b, and c): Diamictites deposits matrix-supported with fragments of granite, quartz, quartzite, flint of various sizes and forms (Ny3lithofaciès, Niamey area)

Figure 9: Striated and faceted pebble in diamictites deposits (Ny3 lithofacies, Niamey area)

4.2. Correlations with Taoudenni and Volta basins

In the Taoudenni and Volta basins, the Proterozoic glacial deposits were assimilated to those of the Triad "tillites, carbonates, cherts" [17], [18], [25], [26]. The Ny3 lithofacies can be used as a reference for this Neoproterozoic glaciation. The polymictic diamictites lithofacies of the Niamey area (Ny3 lithofacies) are the equivalent to the basal deposits (Tillite) of Pendjari Supergroup (Oti) in the Volta Basin. Furthermore, this type of lithofacies corresponds to the T10 deposits (polymict conglomerate) of the Taoudenni basin [13]. A sandstone formation with two kinds of lithofacies (Ny1 and Ny2 lithofacies) was observed in the Niamey area. The basal Ny1 lithofacies is made of quartzitic sandstones with hummocky beddings. It rests unconformably on the Liptako Birimian basement. The lithofacies Ny1 is overlain by fine-grained sandstone (lithofacies Ny2) containing glauconite and showing planar cross beddings. On a larger scale, this sandstone group (Ny1 and Ny2 lithofacies) can be correlated to the Bombouaka Supergroup (sandstone) of the Volta Basin [19] and the T1 deposits (including medium- to coarse- grained glauconitic sandstone) of the Taoudenni basin [13]. Therefore, the Ny1 and Ny2 lithofacies correspond to the basal deposits of the Volta and Taoudenni basins.

However, these lithostratigraphic correlations show that two formations of the "Triad" carbonates and cherts are not observed in the Proterozoic deposits of the Niamey area. There are two explanations for this lack:
(1) The carbonates and cherts were eroded or,
(2) They have not been deposited.
The second hypothesis is more probable. Indeed, Niamey area is located on the eastern edge of West African Craton, therefore on the basin border. This position implies a weak depth that could justify this lack of sedimentation in Niamey area Proterozoic deposits. This is in agreement with the observations of [5] who believes that a very slow rate of subsidence (between 5–15 mm/1000 years) affected the neighboring basins of Taoudenni and Volta.

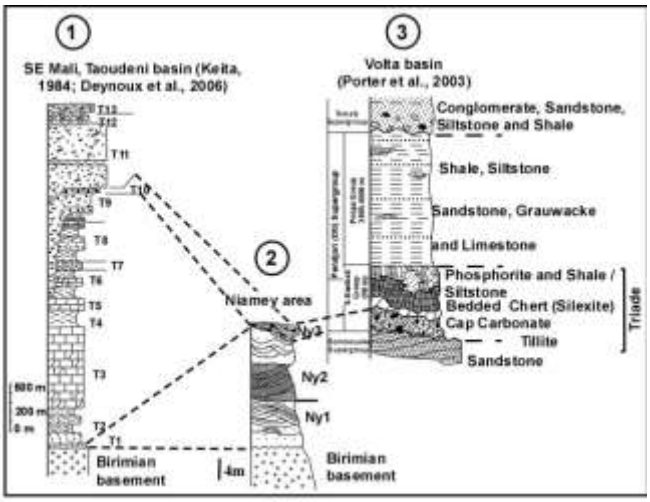

Figure 10: Stratigraphic correlation: Niamey area deposits with Taoudenni and Volta basins [13], [19]. **Taoudenni Basin** T1 Formation: Medium- to coarse-grained glauconitic sandstone T2 Formation: Medium-grained sandstone, siltstones and shales. T3 Formation: Stromatolite-bearing carbonates. T4 Formation: Shales and marls. T5 Formation: Algae and stromatolite-bearing carbonates. T6 Formation: Shales, carbonates and fine-grained sandstone. T7 Formation: Croarse-grained sandstone. T8 Formation: Shales and fine-grain sandstone. T9 Formation: Coarse-grained to conglomeratic sandstone. T10 Formation: Polymict conglomerate. T11 Formation: Medium- to coarse-grained and pebbly sandstone. T12 Formation: Fine- to medium-grained sandstone and shales. T13 Formation: Fine- to medium-grained scolithus sandstone and shales. **Niamey area** Ny1 and Ny2: Quartzitic sandstones. Ny3: Conglomerates deposits (polymictic-diamictite)

5. Conclusion

The siliciclastic sediments of the Niamey region show some lithological similarities with the Late Cryogenian “Triad” sediments of the Taoudenni and Volta basins. It is possible that the basins of the Volta and Taoudenni are originally continuous or have at least one junction between the southern region of Niger and the Taoudenni [16].

The lithofacies observed in Niamey area (Ny1 to Ny2) correspond to the basal deposits of the Volta and Taoudenni basins. The Ny3 lithofacies, interpreted as tillite deposits, described in the Niamey area could be connected to the Neoproterozoic glaciation widely described in the Volta and Taoudenni basins.

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