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U–Pb detrital zircon ages of sediments from the Firgoun and Niamey areas (eastern border of West African Craton, West Niger)

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ABSTRACT

This study uses field observations and new U–Pb ages of detrital zircon grains from three samples to question the stratigraphic position of the Firgoun and Niamey siliciclastic sediments, presumed to be Neoproterozoic in age. Sharing several lithological similarities with the Late Cryogenian “Triad” of the Taoudenni, Gourma, and Volta basins, the uppermost siliciclastic sediments of the Firgoun and Niamey areas were likely also deposited during this period. This is corroborated by matrix-supported diamictites with faceted or striated pebbles as well as by structures resembling cryoturbation processes. However, the detrital zircon U–Pb age record that we present here for the lowermost deposits of Firgoun and Niamey provides mainly Paleoproterozoic ages, and very few Archean ages, altogether in a range from 1822 ± 9 to 3392 ± 9 Ma. Therefore, the new data only show that the Firgoun and Niamey sediments were deposited before about 1800 Ma. Nevertheless, the U–Th–Pb zircon age data allows examining the possible provenance of the sediments. We show that the latter was likely in the westerly close vicinity of the studied areas. The Archean zircons are likely inherited, and possibly originating from a more westerly source. The nearby source of the Niamey and Firgoun sediments suggests that a high topographic relief was still existing in the south-central part of the West African Craton in the Mid Neoproterozoic.

1. Introduction

In Niger, the Firgoun and Niamey sedimentary deposits overlie unconformably the Paleoproterozoic terrains (Birimian Schists and Granites) of the southeastern edge of the West African Craton (WAC). Classically, due to their stratigraphic position, they have been considered as equivalent to the sediments of the neighboring Taoudenni and Gourma basins to the north (Bertrand-Sarfati et al., 1991; Miningou et al., 2017; Reichelt, 1972), and of the Volta basin to the south (Affaton, 1990) (Fig. 1A). However, few studies have been carried out on the Firgoun and

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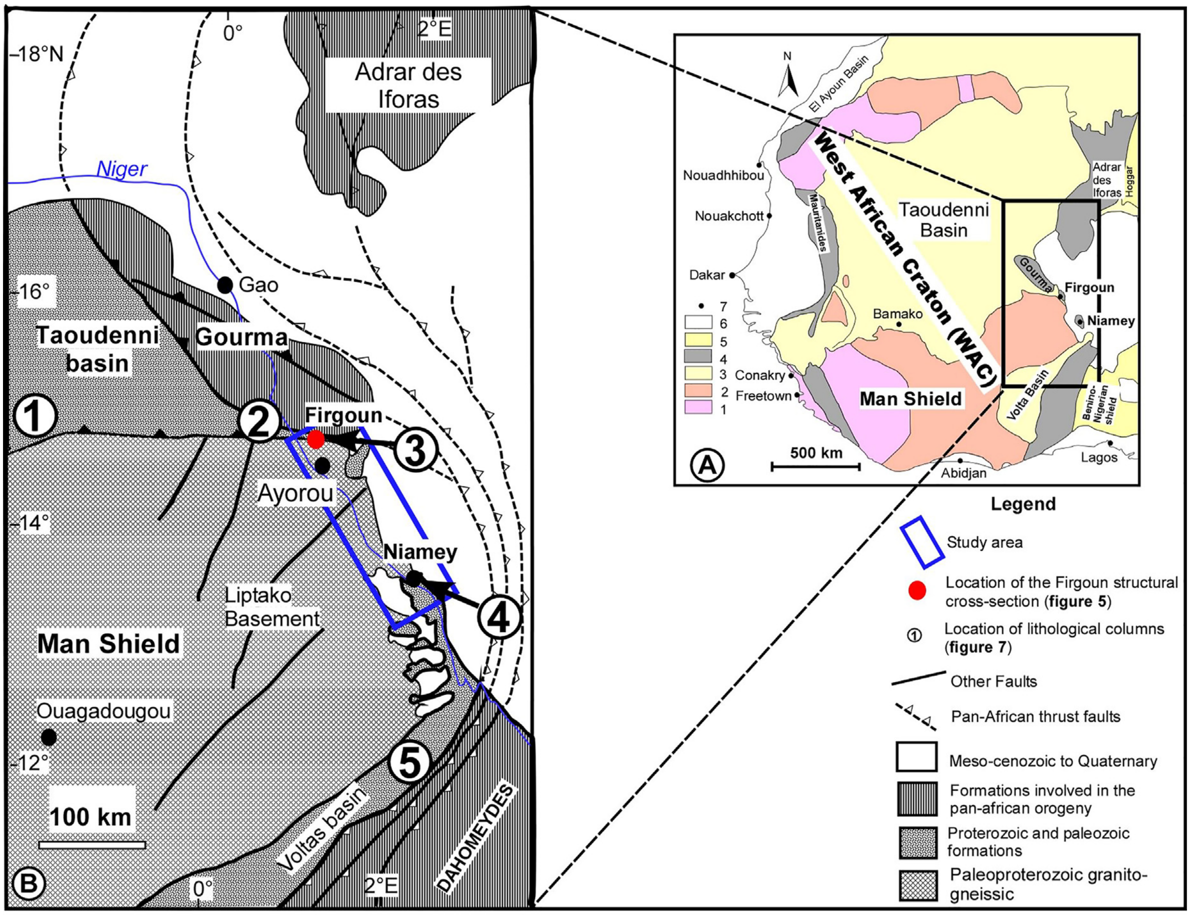


Figure 1 :

Fig. 1. **(A)** Overview map of West African Craton (modified from Trompette, 1973). 1: Archean; 2: Birimian; 3: Palaeozoic basins including the locally-found Late Precambrian; 4: Mobile zones; 5: Eastern continental blocks; 6: Post-Palaeozoic terrains; 7: Towns. **(B)** Enlarged detailed geological map of the northeastern border of Man Shield with the location of the study area, in the structural context of Liptako (southwestern Niger, West Africa, from Affaton et al., 2000, modified).

Niamey sediments, so that their age and origin are still debated.

The Firgoun terrains are considered as the equivalent of the basal deposits of the Ydouban Group of Gourma (Supplementary Table 1) (Machens, 1972; Reichelt, 1972). The Ydouban group comprises, from bottom to top, conglomerates and quartzite sandstones, a pelitic formation (shales), a siliceous formation (cherts and jasper) and a carbonate formation (limestones and dolomites, locally stromatolitic) (Delfour, 1965). Similarly, the Niamey and Firgoun sediments are made of sandstones and conglomerates. The Ydouban Group rests unconformably on the Birimian basement, cratonized around 2400–1900 Ma (Abouchami et al., 1990; Boher et al., 1992; Linnemann et al., 2011; Zhao et al., 2002). The stratigraphic position of the Firgoun and Niamey sediments is still a subject of controversy. According to Bertrand-Sarfati et al. (1991), the Ydouban Group is Late Proterozoic in age, based on the type of stromatolites it contains. However, the position of the “Triad” (tillite, limestones, silexite), which was defined afterwards as a major stratigraphic marker in West Africa (Deynoux et al., 2006; *see next section*), has not been clearly specified in their work (Supplementary Table 1). Machens (1972) considers an Infracambrian or Tarkwaian age for the Niamey sandstone, while Affaton et al. (2000) assign them to the Neoproterozoic. The lack of fossils in these sandstones and conglomerates prevents any biostratigraphic age determination. Therefore, in the present study, we performed U–Pb dating of a large population of detrital zircons collected in three samples from the Firgoun and Niamey sediments.

At least a maximum age of deposition can be deduced from the youngest U–Pb ages of the detrital zircons. However, the actual age of deposition can be much older due to inheritance issues (Cawood et al., 2012).

The U–Pb detrital zircon method provides new information on the non-fossiliferous sediments age and their provenance. The compilation of available zircon ages from the surrounding areas (e.g., Gärtner et al., 2017, 2018, this issue) allows suggesting potential paths of sedimentary transport at the time of sandstone and conglomerate deposition.

Eventually, we discuss the Proterozoic Niamey and Firgoun deposits in their regional context.

2. Geological setting

The Gourma Basin represents the southeastern edge of the Taoudenni Basin. The central part and eastern margin of the West African Craton are gently down-warped to form the Taoudenni and Volta basins (Bertrand-Sarfati et al., 1991). According to their geographical position, the Proterozoic sediments of Firgoun and Niamey represent a link between the Taoudenni and Gourma basins to the north and the Volta basins to the south (Fig. 1B).

In both the Taoudenni and Volta basins, two series could be distinguished. The lowermost Supergroup 1 series consists of Late Mesoproterozoic sandstones (Beghin et al., 2017; Rooney et al., 2010), of stromatolite-bearing limestones, and of dolomites. The uppermost Supergroup 2 series (Vendian–Cambrian in age) includes the "Triad" (Bertrand-Sarfati et al., 1991).

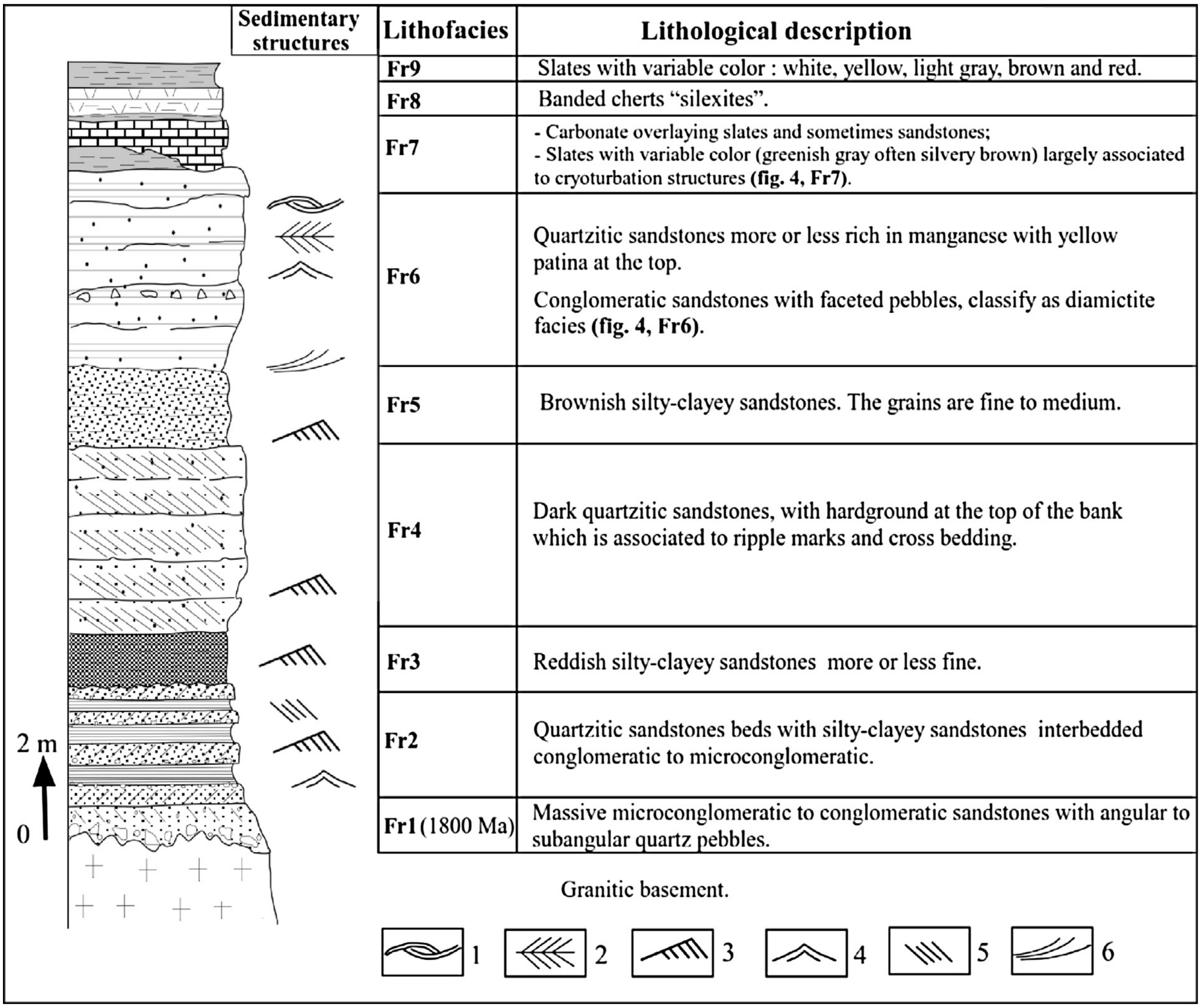
3. Field observations

To illustrate our field observations, two lithostratigraphic columns (Figs. 2 and 3) and a structural cross-section (Fig. 4) have been realized. The lithostratigraphic columns allow establishing the vertical sequence of the lithofacies and the possible occurrence of the "Triad" marker, while the surveyed geological section in the Firgoun area highlights the spatial arrangement of the terrains and the associated deformations.

3.1. Lithostratigraphic column of Firgoun area

The stratigraphic succession of the Firgoun area deposits includes the following lithofacies, from bottom to top (Fig. 2).

Lithofacies Fr 1. It consists of about 1 m of coarse to conglomeratic quartzitic sandstone. The lithofacies Fr1 overlies unconformably the Birimian basement. It displays essentially matrix-supported conglomerates with angular to subangular quartz pebbles.



Lithofacies	Lithological description
Fr9	Slates with variable color : white, yellow, light gray, brown and red.
Fr8	Banded cherts "silexites".
Fr7	- Carbonate overlaying slates and sometimes sandstones; - Slates with variable color (greenish gray often silvery brown) largely associated to cryoturbation structures **(fig. 4, Fr7)**.
Fr6	Quartzitic sandstones more or less rich in manganese with yellow patina at the top. Conglomeratic sandstones with faceted pebbles, classify as diamictite facies **(fig. 4, Fr6)**.
Fr5	Brownish silty-clayey sandstones. The grains are fine to medium.
Fr4	Dark quartzitic sandstones, with hardground at the top of the bank which is associated to ripple marks and cross bedding.
Fr3	Reddish silty-clayey sandstones more or less fine.
Fr2	Quartzitic sandstones beds with silty-clayey sandstones interbedded conglomeratic to microconglomeratic.
Fr1 (1800 Ma)	Massive microconglomeratic to conglomeratic sandstones with angular to subangular quartz pebbles.

Fig. 2. Synthetic lithostratigraphic column of the Firgoun area. 1. Hummocky cross stratifications, 2. Herring bones, 3. Current ripples 4. Wave ripples 5. Planar cross bedding, 6. Planar cross tangential at the bottom.

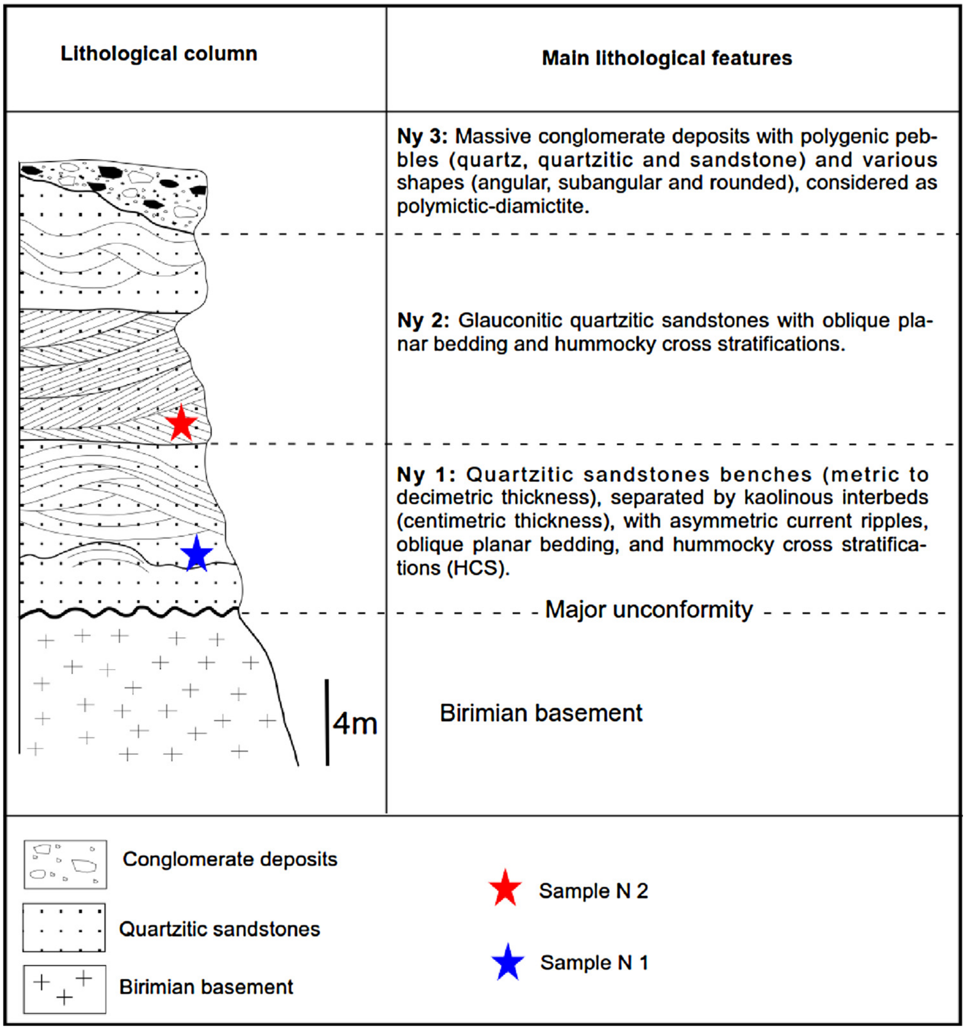


Fig. 3. Synthetic lithostratigraphic column of the Niamey area.

Lithofacies Fr 2. This lithofacies is about 3.5 m in thickness and consists of an alternation of quartzitic sandstones beds with conglomerates to microconglomerates and silty-clayey sandstone layers (Figs. 2 and 4-2). They exhibit oblique bedding layers. The silty-clayey levels become thicker towards the top, while the quartzitic sandstone levels become thinner. This succession is interpreted as a turbiditic sequence.

Lithofacies Fr 3. It consists of silty-clayey sandstone deposits, more or less fine-grained, and about 1.5 m in thickness.

Lithofacies Fr 4. It consists of rusted dark quartzite beds (up to 4 m in thickness), with fine to medium grain-size, showing flat crest ripples that are associated with hardgrounds.

Lithofacies Fr 5. Fr5 is represented by fine-to medium-grained sandstones that are brownish and silty-clayey. These sandstones usually exhibit asymmetric ripples indicating a SW–NE paleocurrent direction on average.

Lithofacies Fr 6: It corresponds to more or less manganese-rich quartzitic sandstones beds, about 5 m in thickness (Fig. 4-3 and 4-8). The intermediate deposits are sandy matrix-supported conglomerate with faceted pebbles (Fig. 5-Fr 6b). They could be considered as diamictite. To the top, the main sedimentary structures observed are represented by symmetric ripples, herring bone structures, and hummocky cross-stratification. All these structures are typical of a shallow marine environment.

The occurrence of the diamictite deposits interbedded into the marine deposits could be interpreted as ice-rafted debris of sediments from glaciers and/or rainouts of icebergs in the marine substrate.

Lithofacies Fr 7. The slates overlie by place quartzitic sandstones in the northern part of the Firgoun area (Figs. 2 and 4-4). Locally, the slates present upturned beds, which are likely related to cryoturbation structures (Fig. 5–Fr7). To the top, the slates are overlain by carbonate rocks about 1 m in thickness. Two kinds of subfacies have been observed, i.e. unmetamorphosed brown dolomitic limestones and white marbles. Marbles are massive deformed rocks (metacarbonates), with a milky white to pinkish appearance. These marbles, about 0.5 m in thickness, often display fractured surfaces (Fig. 4-7).

Lithofacies Fr 8. It consists of greenish to black banded silexites about 1 m in thickness, exhibiting a conchoidal break (Fig. 4-5).

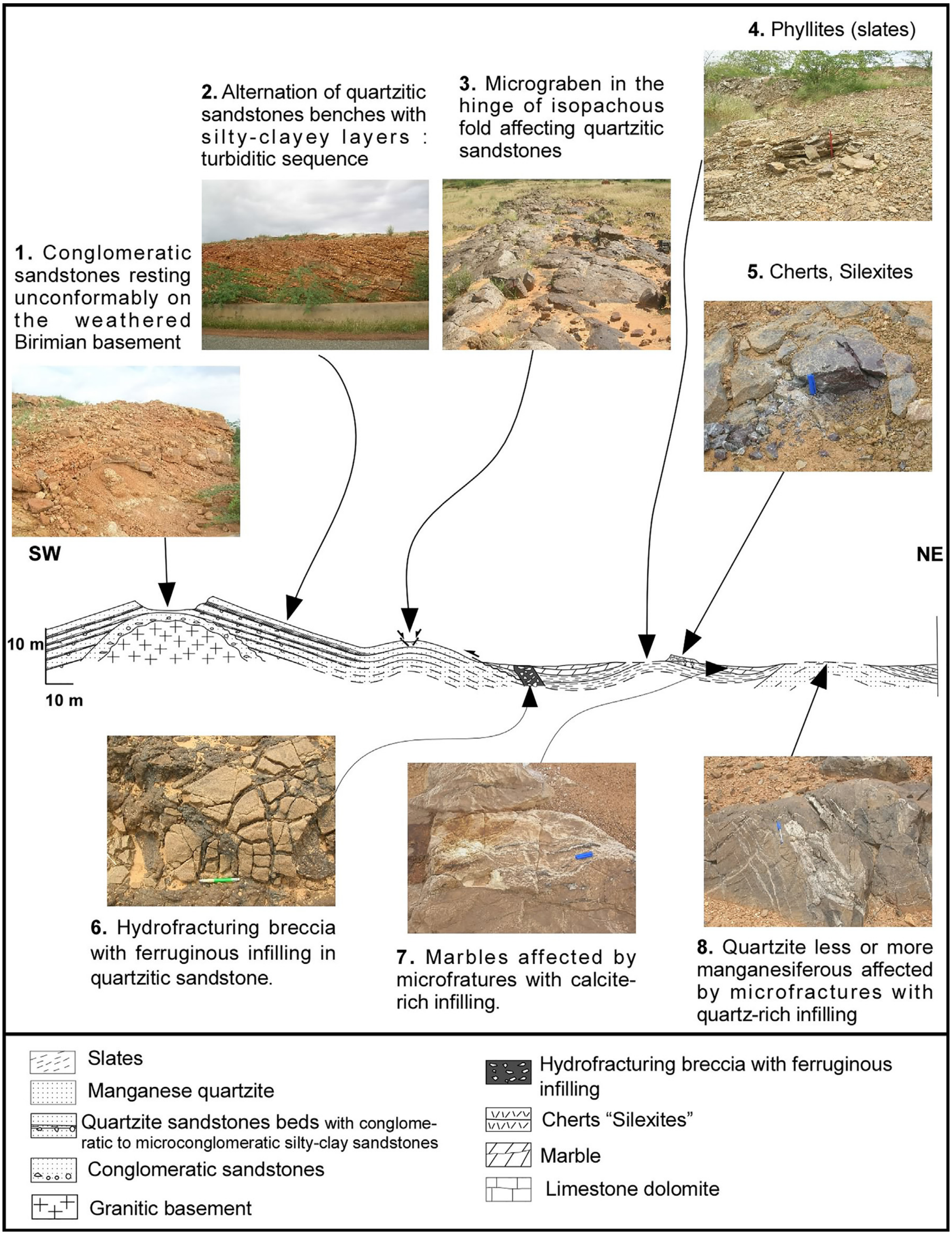


Fig. 4. Structural cross-section of the Firgoun area realized from SW to NE (location in Fig. 1-B).

Lithofacies Fr 9. Varied colors are observed in this lithofacies: white, yellow, light gray, brown and red. Thin intercalations of sandstones and silexites are observed.

3.2. Lithostratigraphic column of the Niamey area

Deposits in the Niamey area consist of quartzitic sandstones preserved in small grabens within the Birimian

Fig. 5. Sedimentary structures observed in the Firgoun and Niamey areas.

basement. They have the same characteristics as the basal sandstones of Firgoun: metric to decametric bedding thickness, hummocky cross-stratification, herring-bone structures, symmetric ripples, and ripple marks. This may allow correlating the Niamey sandstones to the basal series of Firgoun.

In the Niamey area, we carried out a synthetic column (Fig. 3) exhibiting three types of lithofacies: 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).

Lithofacies Ny1. It 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 were deposited in the form of beds of metric to decimetric thickness with hummocky beddings.

Lithofacies Ny2. The fine-grained quartzitic sandstone with relatively blunt quartz grains shows several types of sedimentary structures (Fig. 3). These are symmetrical and asymmetrical current ripples indicating a SW–NE paleocurrent direction on average, planar cross bedding, and hummocky cross stratification. The presence of glauconite in the Karey Gorou area is an indicator of a shallow marine environment.

Lithofacies Ny3. These are conglomeratic deposits that lie unconformably on quartzitic sandstones (Fig. 5-Ny3). They exhibit matrix-supported, centimetric to decimetric fragments of rocks of variable composition such as granite, quartz, quartzite, flint of various sizes and forms (angular, subangular, rounded) (Fig. 5-Ny3). The pebbles frequently show parallel tabular faces and a pentagonal shape (faceted pebbles), and they are sometimes striated. Placed on their large face, these pebbles show a flat iron shape. Due to their appearance, these pebbles exhibit characteristics of glacial deposits. Therefore, these polymictic rock fragments may be considered as possible tillite, deposited in a floating ice context.

3.3. Firgoun structural cross-section

We realized a structural cross-section of the Firgoun area, from SW to NE. This cross-section shows the presence of small-scale anticlinal and synclinal structures (Fig. 4). The Firgoun terrains, resting unconformably on the Birimian basement, exhibit several types of deformation structures (Fig. 4). In the northern part of the Firgoun area, these quartzitic sandstones show developed fold structures that correspond to disharmonic anisopach folds with hinge deformation (Fig. 4-3).

Manganese-rich quartzites are transgressive on the sandstone series (Fig. 4-8). These quartzites are in close contact with greyish shales. They are frequently dissected by stepped fractures.

The phyllites (slates) are characterized by a lateral succession of small-scale syncline-anticline structures including carbonate levels (dolomitic limestones) that are more or less recrystallized (Fig. 4-4).

Laterally, to the east, slates gradually become chert. The carbonates are represented by marbles, which overlay the phyllites (Fig. 4-7).

4. U–Pb detrital zircons study

4.1. Sample preparation

Sample preparation was done using standard methods of heavy mineral separation and CL imaging prior to LA–ICP–MS analysis at the Senckenberg Naturhistorische Sammlungen, Dresden, Germany (see the corresponding supplementary data file available on the journal website for further details).

4.2. U–Th–Pb age determination via LA–ICP–MS

Measurements for U, Th and Pb were executed at the GeoPlasma Lab, Senckenberg Naturhistorische Sammlungen Dresden using LA-ICP-MS (Laser Ablation with Inductively Coupled Plasma Mass Spectrometry) techniques. A Thermo-Scientific Element 2 XR instrument coupled with an ASI RESOlution SE S155 193 nm Excimer Laser System was utilized (for data *see* Supplementary Table 2). All analyses were performed at a spot size of 35 μm. More detailed specifications on the instruments settings are available in Supplementary Table 2. Discordant analyses were generally interpreted with caution, even if they define a discordia. Production of concordia diagrams (2σ error ellipses) and concordia ages (95 % confidence level) was achieved using Isoplot/Ex 2.49 (Ludwig, 2001). Frequency as well as relative probability plots were generated via Age Display (Sircombe, 2004).

4.3. Results

Three samples of siliciclastic sediments, F1, N1, and N2, were studied for their detrital zircon U–Th–Pb age record (Fig. 6). A total amount of 465 grains was analyzed for their U–Th–Pb isotope composition with 168 zircons yielding age values with a concordance between 90 and 110% (= concordant grains). The given Th–U values refer to concordant measurements. The obtained isotope results for each grain can be found in Supplementary Table 3. Results of age determination are depicted in Fig. 6.

Sample F1, N14°49′55.7″, E0°53′07.7″, massive conglomeratic sandstone (Fig. 2-Fr1)

Sample F1 was taken from a yellowish-brown, massive conglomeratic sandstone in the Firgoun area, which rests unconformably above the Birimian basement. Of 163 analyzed zircon grains, 78 yielded concordant ages between 2037 ± 12 Ma and 2285 ± 17 Ma, with the largest group between 2175 and 2194 Ma (Fig. 6). However, this sample shows a remarkably narrow spectrum of detrital zircon ages, which is additionally enhanced by the discordia array of the discordant analyses. An exception is a group of six discordant grains defining a discordia line with an upper intercept at 2410 ± 8 Ma. The obtained Th–U values range from 0.14 to 0.65.

Sample N1, N13°33′59.1″, E2°00′37.5″, quartzitic sandstone (Fig. 3-Ny 1)

The whitish-grey, well-sorted quartzitic sandstone N1 sample was collected in the Niamey area. Out of all 163 analyzed grains, 46 gave concordant ages between 1869 ± 11 and 2829 ± 13 Ma, with main peaks around 1900, 2100, and 2200 Ma (Fig. 6). A significant sub-peak at approximately 2440 Ma is further corroborated by a discordia line defined by eight zircons with an upper intercept age at 2436 ± 17 Ma. Most of the discordant grains are in a sector defined by discordia lines with upper intercepts between ca. 1800 and 2200 Ma. The Th–U elemental ratios are between 0.26 and 0.92.

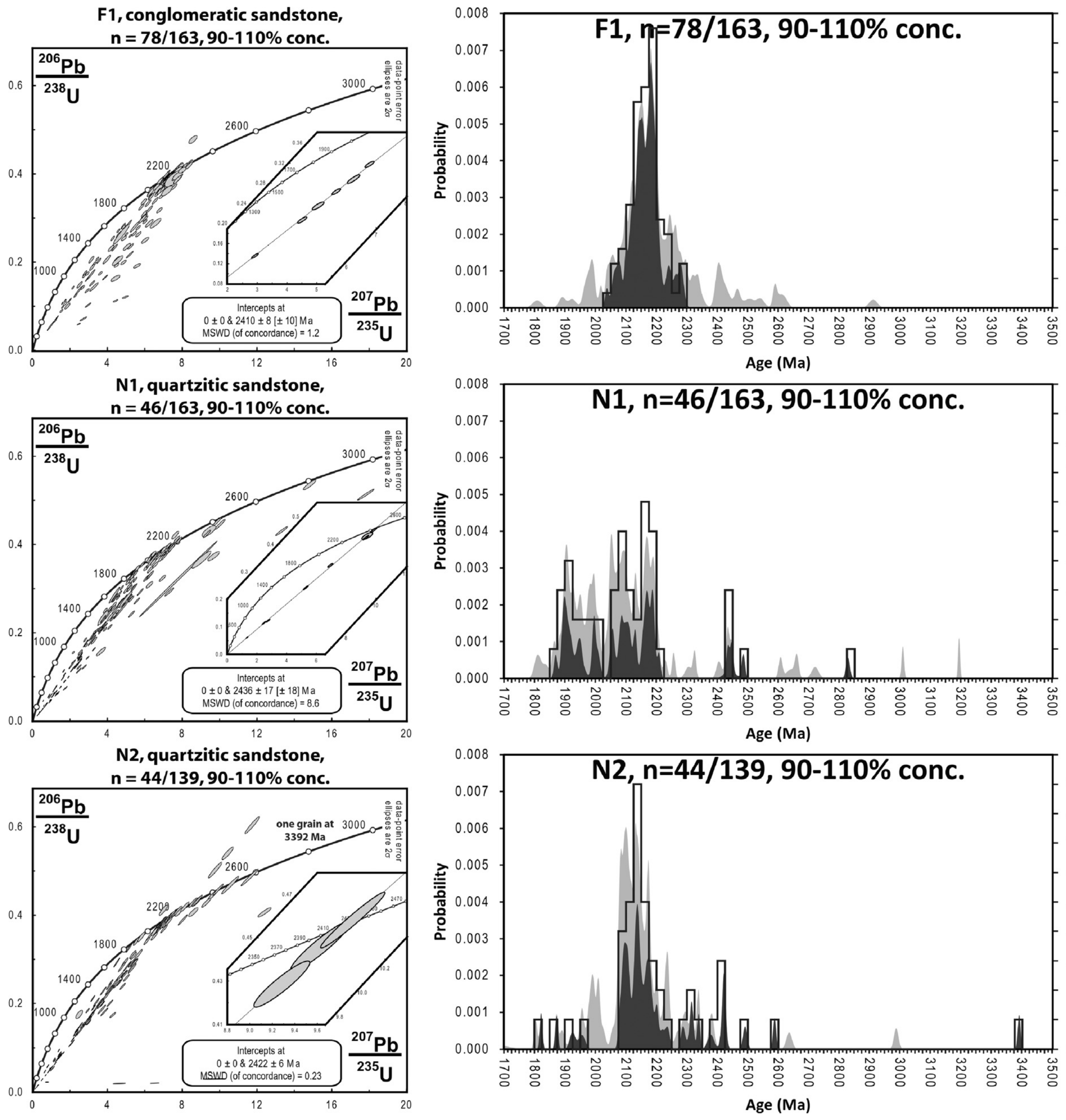


Fig. 6. Concordia plots of samples F1, N1, and N2 (left) as well as binned frequency probability density plots of the same samples (right, bin width = 25 Ma).

Sample N2, N13°34′03.8″, E2°00′35.5″, quartzitic sandstone (Fig. 3-Ny 2)

A medium-grey, well sorted quartzitic sandstone (N2) was sampled in the Niamey area. The rock shows the same sedimentologic characteristics as sample N1. Out of 139 zircon grains analyzed for their U–Th–Pb isotopic composition, 44 yielded concordant ages from 1822 ± 9 to 3392 ± 9 Ma (Fig. 6). The main peak is at about 2140 Ma, while minor peaks occur at ca. 2100, 2180, and 2420 Ma. Combination of the three ages around 2420 Ma leads to a discordia upper intercept age at 2422 ± 6 Ma. Most values of discordant analyses plot in a sector bordered by discordias with upper intercepts between ca. 1800 and 2200 Ma. Th–U values range from 0.10 to 0.83.

5. Discussion

5.1. Lithostratigraphic correlations

In the Taoudenni and Gourma basins, the Proterozoic glacial deposits were assimilated to those of the Triad (Miningou et al., 2010, 2017; Villeneuve, 2006).

Preliminary research has shown that the only deposits of the Triad component are represented by cherts and

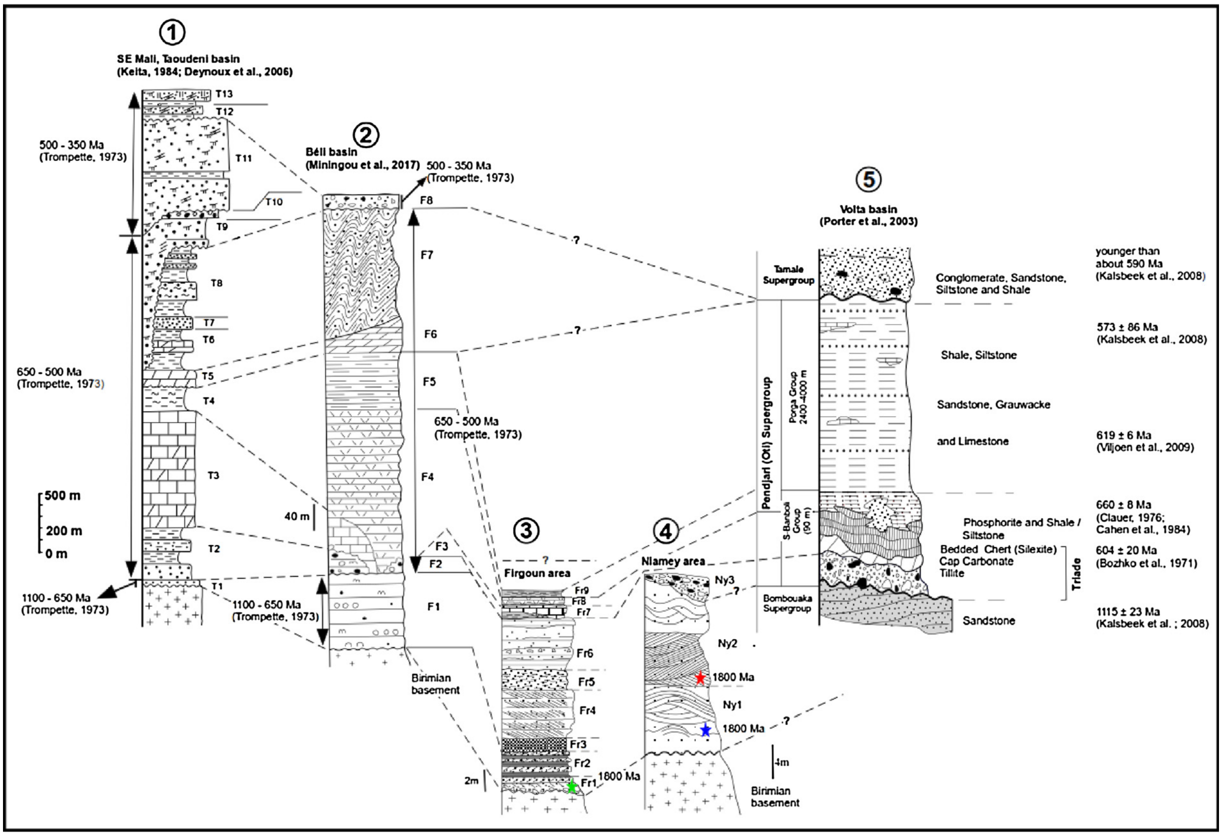


Fig. 7. Stratigraphic correlation with the Taoudenni, Béli and Volta Basins (Deynoux et al., 2006; Keïta, 1984; Miningou et al., 2017; Porter et al., 2003). Taoudenni Basin. T1: Medium- to coarse-grained glauconitic sandstone. T2: Medium-grained sandstone, siltstones, and shales. T3: Stromatolite-bearing carbonates. T4: Shales and marls. T5: Algae and stromatolite-bearing carbonates. T6: Shales, carbonates, and fine-grained sandstone. T7: Coarse-grained sandstone. T8: Shales and fine-grained sandstone. T9: Coarse-grained to conglomeratic sandstone. T10: Polymictic conglomerate. T11: Medium- to coarse-grained and pebbly sandstone. T12: Fine- to medium-grained sandstone and shales. T13: Fine- to medium-grained scolithus sandstone and shales. Béli Basin. F1: Coarse-grained to conglomeratic quartzitic sandstone. F2: Diamictite. F3: Limestone. F4: Silexitic complex. F5: Shales and siltstones. F6: Dolomite. F7: Phyllites. F8: Molasse.

carbonates. However, the presence here, exposed for the first time, of faceted pebbles in diamictites and “cryoturbation structures” in slates, attributed to freezing and thawing phenomena, is an important indication that at least one of the Mesoproterozoic to Ediacarian glacial episodes has affected this region.

The lithofacies observed in the areas of Niamey (Ny1 to Ny2) and Firgoun (Fr1 to Fr6) correspond to the basal deposits of the Volta, Béli, and Taoudenni basins (Fig. 7). The potential Ny3 tillites observed in the Niamey sector could be connected to the Neoproterozoic glaciation widely described in the Volta, Béli, and Taoudenni basins. Moreover, in the Firgoun sector, the occurrence of diamictite deposits with faceted pebbles (lithofacies Fr6), interbedded into the marine deposits and the presence of more or less recrystallized limestone (Fr7 lithofacies) and silexites (Fr8 lithofacies) could be considered as parts of the well-known Neoproterozoic Triad. In the Béli Basin of Burkina Faso, the Triad overlays quartzitic sandstones (Miningou et al., 2017) as in the studied regions of Niamey and Firgoun.

On a larger scale, the sandstone formations of the Niamey and Firgoun areas could correspond to the Bombouaka Supergroup of the Volta Basin (Porter et al., 2003), the F1 lithofacies of the Béli Basin (Miningou et al., 2010, 2017) and the T1 deposits of the Taoudenni Basin (Deynoux et al., 2006; Keïta, 1984) (Fig. 7). The polymictic diamictites lithofacies of the Niamey region (Ny3) are equivalent to the basal deposits of Pendjari Supergroup (Oti) in the Volta Basin (Fig. 7). Furthermore, this type of facies corresponds to the F2 Formation of the Béli Basin (Miningou et al., 2010, 2017).

The Fr1 lithofacies of the Firgoun region is the equivalent of the F1 Formation of the Béli Basin (Miningou et al., 2010, 2017) and could be related to the T1 Formation of the Taoudenni Basin (Deynoux et al., 2006; Keïta, 1984) (Fig. 7). The Fr7 (phyllites followed by carbonates) and Fr8 (silexites) lithofacies of the Firgoun region may represent equivalents of the carbonate–silexite association of the Pendjari Supergroup of the Volta Basin (Porter et al., 2003). These Fr7 and Fr8 formations are comparable to the Béli Basin F3 and F4 formations (Miningou et al., 2010, 2017), as well as to the T3 and T4 formations of the Taoudenni Basin (Deynoux et al., 2006; Keïta, 1984). The Fr9 lithofacies (phyllites) of the Firgoun region corresponds to the phosphorite shales and siltstones (top of the South Bamboli Group) in the Volta Basin (Porter et al., 2003).

This Fr9 lithofacies is equivalent to the F5 Formation of the Béli Basin (Miningou et al., 2010, 2017) and the top of T4 of the Taoudenni Basin Deynoux et al., 2006; Keïta, 1984).

5.2. Potential sources of Firgoun and Niamey sandstones

Beside a total of three Archean analyses from samples N1 and N2 at 2588 ± 10, 2829 ± 13, and 3392 ± 9 Ma, the remaining detrital zircon ages are Paleoproterozoic (2492 ± 14 Ma to 1822 ± 9 Ma). Thus, the detrital zircon record is not suitable to bracket the time of sedimentary deposition more precisely than < ca. 1800 Ma.

Given the potential Mid to Late Neoproterozoic age of the Firgoun and Niamey sediments as inferred from the partial similarities with coeval strata forming the “Triad” in the Taoudenni and Gourma basins (*see above*), the age spectrum of the detrital zircons is regarded as indicative of the source area and direction of sediments transport at that time. The absence of Neoproterozoic and Mesoproterozoic zircons excludes the western margin of the West African Craton (Bradley et al., 2013; Gärtner et al., 2013; Straathof, 2011), as well as most strata of the Volta Basin and parts of Nigeria (Kalsbeek et al., 2008, 2012), as sources for the studied sediments (Fig. 8), where such zircon ages are abundant. The same applies to the Hoggar area as characterized by Bechiri-Benmermzoug et al. (2017). Consequently, sediment transport over long distances from the northwest, north, and south-southeast does not seem to have played a major role (Fig. 8).

Using the compilation of zircon ages of the West African Craton published by Gärtner et al. (2017), it becomes likely that the source area of the studied Niger sediments is the surrounding Leo-Man Shield, which almost exclusively contains the obtained zircon age spectra in comparable age–probability–frequency distribution patterns. Furthermore, there are striking similarities with some of the lowermost sediments of the Volta Basin, as reported by Kalsbeek et al. (2008, sample Gh3 of the Bombouaka Group). The detrital zircons of the latter represent a short episode and a special case in the Volta Basin’s sediments, and were potentially fed by the same source as those of Firgoun and Niamey (Fig. 8).

The local age distribution of igneous rocks (e.g., Ama Salah et al., 1996; Soumaila et al., 2008; Tapsoba et al., 2013) and the detrital zircon ages from Paleoproterozoic sediments of the Liptako province of SW Niger (Soumaila

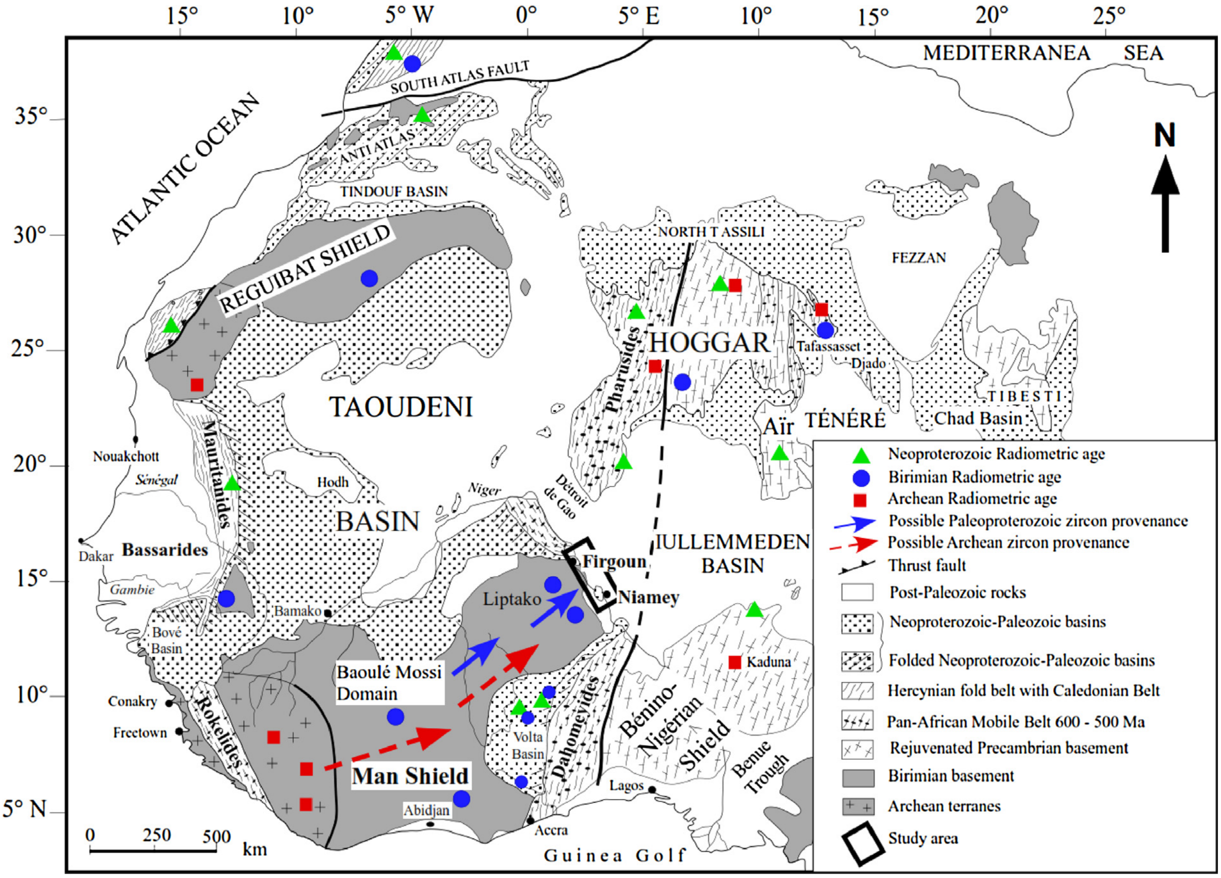


Fig. 8. Sketch map of West Africa (modified from Trompette, 1973). Radiometric dates are compiled from the publications of Hellal (1987); Bossière et al. (1996); Kröner et al. (2001); Lahondère et al. (2002); Schofield et al. (2006); Kalsbeek et al. (2008); Vidal et al. (2009); Soumaila et al. (2008); Caby & Kienast (2009); Dabo (2011); Gärtner et al. (2013); Gärtner et al. (2016); Rollinson (2016); Peucat et al. (2003); Fezaa et al. (2010); Ouabid et al. (2017). The blue arrows indicate the direction from the potential source areas of Paleoproterozoic zircon, while the red ones correspond to the possible Archean zircon provenance.

et al., 2008) are almost identical to those of the Firgoun and Niamey sediments, except for the Archean zircons. However, the latter zircons may represent a detrital component resulting from multiple cycles of sedimentary recycling, and thus, could originate from the Early Archean rocks of the West African Craton (e.g., Guelemata gneiss, ca. 3542 Ma, granites of Liberia ca. 2797–2907 Ma, Thiéblemont et al. (2004); migmatitic orthogneiss of Amsaga ca. 3450–3500 Ma, Potrel et al., 1996), the Benin–Nigeria Shield (migmatitic orthogneiss of Kaduna ca. 3571 ± 3 Ma, Kröner et al., 2001), or the Hoggar charnockites (ca. 3473–2946 Ma, Bechiri-Benmermzoug et al., 2017; Fig. 8). However, due to the possible multiple recycling, the few Archean detrital zircons are not indicative of any provenance reconstruction at the time of deposition of the sediments. Regarding the Paleoproterozoic detrital zircon age pattern, it is possible that the studied sediments originated from the western part of the West African Shield.

The age distribution plots show three major peaks (at 2200, 2100 and 1900 Ma; Fig. 6) and one sub-peak (2410 to 2440 Ma; Fig. 6). These different peaks correspond to the main events of the Eburnean orogeny:

- the sub-peak at 2440 to 2410 Ma coincides with the age of the earliest stages of the Eburnean orogeny (Lemoine, 1988), and hence the corresponding zircon may have formed during these stages;
- the peak at 2200 to 2100 Ma corresponds to the largest fraction of zircon ages. This span of ages coincides with the main phase of the Eburnean orogeny;
- the peak at 1900 Ma is likely related to the late-orogenic granitization period (Barbey et al., 1989; Ama Salah et al., 1996).

Following this interpretation, the Firgoun and Niamey area sediments could have been deposited on a continental margin, after a widespread weathering of the uplifted Eburnean Orogen. As the detrital zircons are interpreted to originate from a western provenance, the southern central parts of the West African Craton likely still represented an elevated area during the Mesoproterozoic to Ediacarian period.

Plotting on the West African map the zircon ages obtained by U–Pb methods (Gärtner et al., 2017) indicates that the Firgoun and Niamey areas detrital zircon provenance could be the western part of the West African Craton (Man Shield).

6. Conclusion

The uppermost siliciclastic sediments of the Firgoun and Niamey regions show some lithological similarities with the Late Cryogenian “Triad” sediments of the Taoudenni, Gourma, and Volta basins. However, the lowermost studied sediments exclusively yielded Archean and Paleoproterozoic detrital zircon ages. The lack of Neoproterozoic zircon ages hampers any precise determination of the age of sedimentation based on this method. On the other hand, the detrital zircon age distribution pattern suggests a mostly western and local provenance. The presented data lead to the conclusion that the West African Craton is the potential source of the Firgoun and Niamey detrital zircon grains, whose ages range from 3392 ± 9 Ma to 1822 ± 9 (Archean to Paleoproterozoic). Additionally, it appears that these sediments have well recorded the main phases of Eburnean crustal growth in their vicinity. These facts suggest that a high topographic relief was still existing in the south-central part of the West African Craton in the Mid Neoproterozoic.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.crte.2018.06.005.

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