ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26jan499

Sedimentological and Structural Control of the Intra-Tarat Division of the South Tamgak Sector (Arlit, Northen Niger)

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Publication Date: 2026/01/20

Abstract: The Arlit mining district ranks among the most important sedimentary uranium provinces in the world. The uranium mineralization exploited by SOMAÏR is mainly hosted within Carboniferous fluvio-deltaic sandstones of the Tarat Formation (Tim Mersoï Basin). This study provides an original synthesis of sedimentological and structural data acquired in the southern Tamgak area, with particular emphasis on the intra-Tarat stratigraphic subdivision and its tectono-sedimentary significance. The study integrates lithological data from drill cuttings, geophysical well logs (natural gamma ray, spectral gamma ray, resistivity, caliper and spontaneous potential), as well as sedimentological and structural field observations carried out in the Tamgak quarry. Stratigraphic correlations and geological cross-sections were established using the WellCAD and SERMINE software. The results show that, in the southern Tamgak sector, the Tarat Formation is reduced to two main lithological units (U1 and U3), whereas units U2 and U4 described elsewhere in the basin are absent. This stratigraphic simplification is interpreted as the result of synsedimentary tectonic activity related to the reactivation of inherited fault systems trending N–S, N30°E and N70°E, in particular the Arlit Fault. These structures controlled accommodation space, the distribution of sediment thicknesses, and local erosion processes, with direct implications for fluid flow pathways and the emplacement of uranium mineralization. The proposed geological model thus provides new insights for uranium exploration in structurally complex sectors of the Tim Mersoï Basin.

Keywords: *Uranium Mineralization; Tarat Formation; Synsedimentary Tectonics; Tim Mersoï Basin; Arlit (Niger).*

How to Cite: Ousmane Loumoumba Moussa Mahaman; Karimou Dia Hantchi; Rachid Boubacar Oumarou; Ahmed Yacouba Liboré; Moussa Konaté (2026) Sedimentological and Structural Control of the Intra-Tarat Division of the South Tamgak Sector (Arlit, Northen Niger). *International Journal of Innovative Science and Research Technology*, 11(1), 1205-1213. https://doi.org/10.38124/ijisrt/26jan499

I. INTRODUCTION

Uranium deposits encased in sandstone constitute a major class of uranium resources and are widely developed in intracratonic basins characterised by a strong tectonic heritage ([1]; [2]; [3]). The Tim Mersoï basin is a prime example of this. It is home to several world-class deposits that have been mined since the late 1960s. In the Arlit mining district ''Fig 1'', uranium mineralisation is hosted in fluvial to fluvial-deltaic Carboniferous sandstones of the Guézouman and Tarat formations ([4]; [5]; [6]).

Although the regional stratigraphy of the Tarat Formation is classically subdivided into four lithological units, significant lateral variations are observed at the deposit scale. In several areas, including Tamgak Sud, certain intermediate units are locally absent, suggesting significant tectono-sedimentary control during their deposition. The overall

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26jan499

objective of this study is to explain this situation. Specifically, it aims to: (i) establish an intra-Tarat division in the Tamgak Sud sector; (ii) characterise the sedimentological and geophysical signatures of the identified units; and (iii) discuss the role of synsedimentary tectonics in controlling the stratigraphy and uranium mineralisation potential.

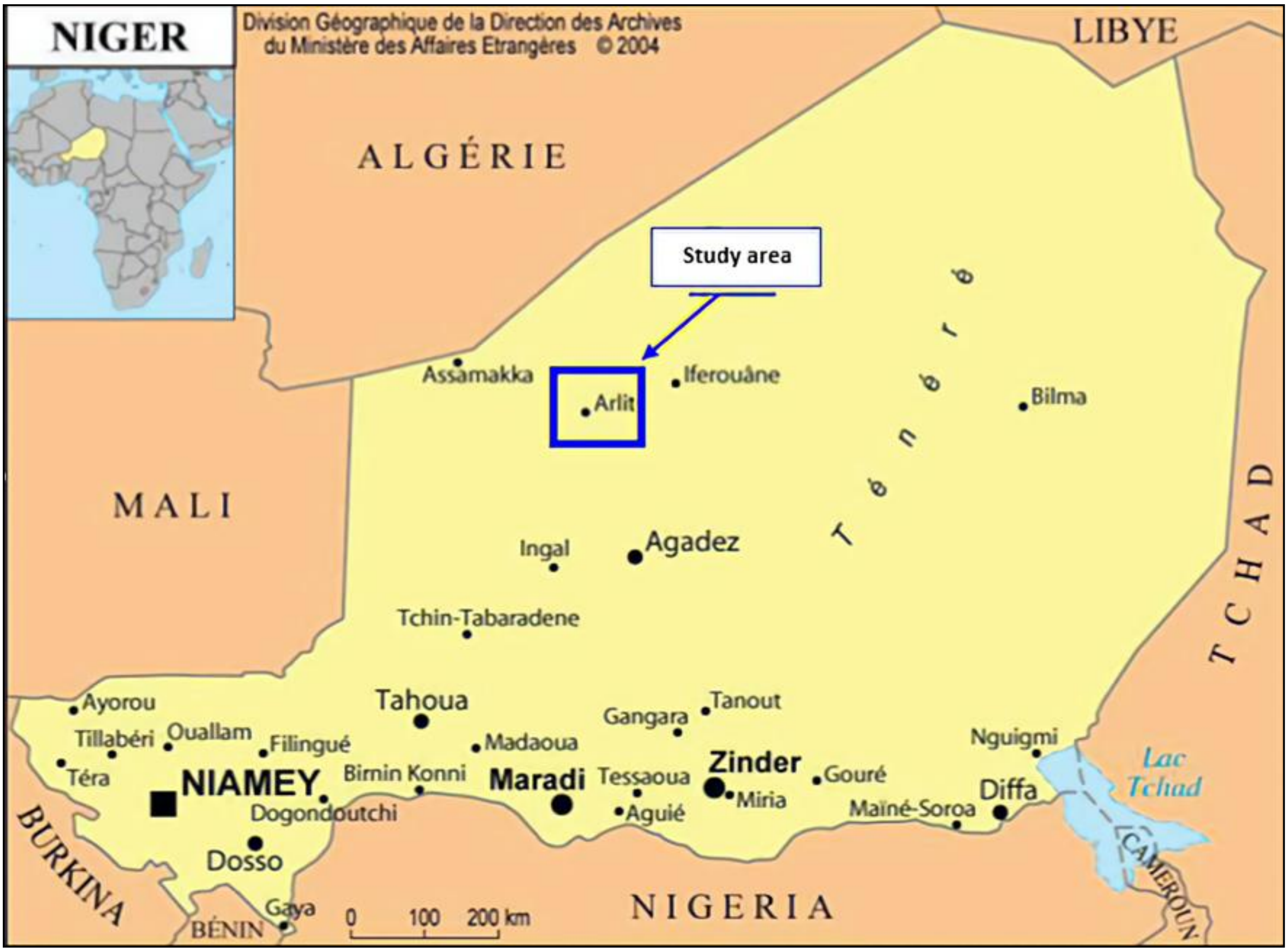

Fig 1 Map Showing the Geographical Location of the Town of Arlit
(Geographical Division of the Archives Directorate of the Ministry of Foreign Affairs, 2004, modified by [7]).

II. METHODS

➢ *Data Acquisition*

This study is based on an integrated analysis of subsurface geological and geophysical data acquired during uranium exploration campaigns in the Tamgak South sector of the Tim Mersoï Basin. The dataset consists of approximately one hundred exploration boreholes drilled on a regular grid with an average spacing of about 50 m, providing high lateral resolution across the study area. The average borehole depth is approximately 100 m, allowing full penetration of the Tarat Formation and its immediate stratigraphic context.

Lithological information was obtained from systematic macroscopic descriptions of drill cuttings collected at regular intervals of 1 meter. The descriptions focused on grain size, color, sorting, clay content, cement type, the presence or absence of organic matter, and other visible sedimentary characteristics when identifiable. These observations were used to define lithological facies and identify major lithostratigraphic boundaries.

Geophysical borehole logging included natural gamma-ray, spectral gamma-ray, resistivity, spontaneous potential (SP), caliper and borehole deviation logs, as described in the original exploration workflow. Gamma-ray logs were primarily used to discriminate clay-rich intervals from cleaner sandstone units, while resistivity and SP logs were used to identify permeable horizons, lithological contrasts and possible fluid-related anomalies.

➢ *Data Processing and Integration*

All lithological and geophysical data were digitised, standardised and integrated using WellCAD and SERMINE software. This processing included depth matching between cuttings and geophysical logs, correction of depth shifts, and standardisation of log scales to ensure consistency across boreholes.

Correlation markers were defined based on the combined interpretation of lithological changes and geophysical log signatures, particularly abrupt shifts in gamma-ray and resistivity responses. These markers were used to correlate

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stratigraphic units laterally between boreholes and to construct geological cross-sections along selected profiles.

The correlation process followed an iterative workflow in which initial correlations were tested, refined, and validated by comparison with neighboring drill holes and consistency checks along intersecting geological sections. This approach reduces interpretation bias and improves the robustness of the stratigraphic framework.

➢ *Structural and Stratigraphic Interpretation*

Geological cross-sections were constructed along both north–south and west–east orientations to capture the main structural trends of the area. These sections were used to identify thickness variations, stratigraphic truncations, onlap relationships and possible structural offsets.

Structural features such as faults and flexures were interpreted based on vertical and lateral variations in sedimentation, abrupt changes in thickness, and local distortions in logging profiles. Particular attention was paid to the spatial relationship between these features and known regional structural elements, such as the Taoussa dome and the Tchinézogue high plateau.

Stratigraphic units (U1, U3 and associated intervals) were defined as informal lithostratigraphic units for correlation purposes, based on consistent lithological and geophysical characteristics rather than formal regional stratigraphic nomenclature.

➢ *Data Quality and Limitations*

The regular borehole grid and high spatial density provide a strong basis for mapping lateral variations and identifying first-order stratigraphic and structural controls. However, several limitations must be considered:

- The vertical resolution of cuttings and logs limits the detection of thin beds and subtle sedimentary structures.
- Cuttings may be affected by downhole mixing and lag effects, introducing uncertainty in exact depth assignments.
- Structural interpretations are based on indirect evidence (log correlations and thickness variations) rather than direct imaging of faults.

As a result, the interpretations presented here focus on metre-scale stratigraphic units and first-order tectono-sedimentary controls, and should be regarded as conceptual rather than definitive models.

➢ *Summary of Methodological Approach*

In summary, this study combines high-density drilling data, lithological descriptions, geophysical logs, and integrated correlation based on high-precision software to construct a strong stratigraphic and structural model of the southern Tamgak area. This integrated approach provides a reliable framework for interpreting the sedimentary architecture and its tectonic controls, and for evaluating its implications for uranium mineralization.

III. RESULTS

➢ *Lithological Units of the Tarat Formation*

Observation of cuttings from the TAM-2573 borehole ‘’Fig. 2’’ revealed four formations outcropping in the Tamgak South sector, including the Tarat Formation. These formations are distinguished by their petrographic characteristics, namely colour, grain size and binder type.

Two main lithological units were identified in the Tarat Formation within the Tamgak South sector ‘’Fig. 3’’:

- Unit U1: medium to coarse sandstone, locally interbedded with clayey and silty levels. The sandstones are generally grey to dark grey, moderately well sorted and show variable cementation, suggesting fluctuating energy deposition conditions in a proximal fluvial to fluvial-deltaic setting;
- Unit U3: coarse to very coarse sandstone, locally micro-conglomeratic, yellowish-grey in colour, characterised by low clay content and high textural maturity, indicating high-energy deposition environments;

Units U2 and U4, described in other sectors of the basin, are not observed in either the cuttings or the diagraphic records.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26jan499

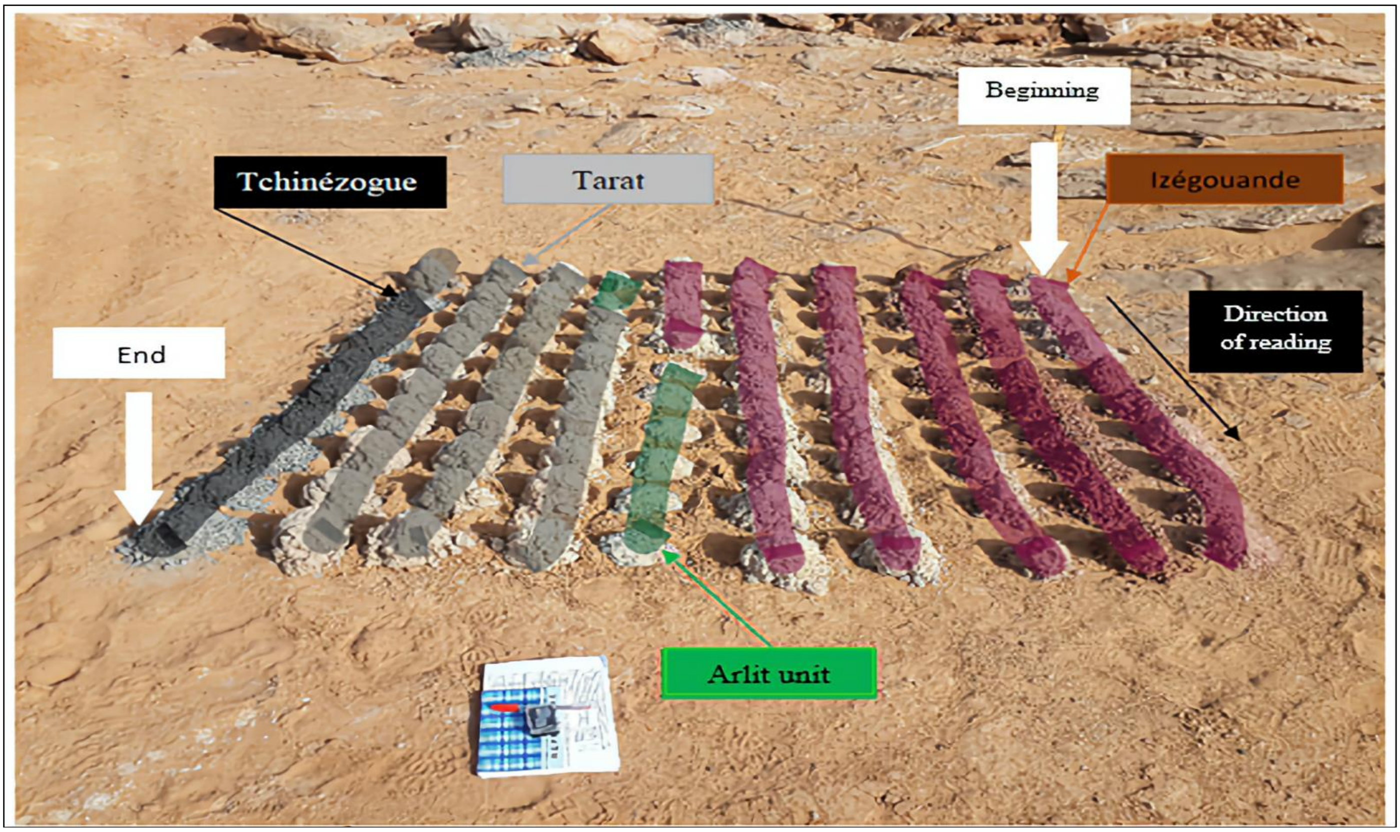
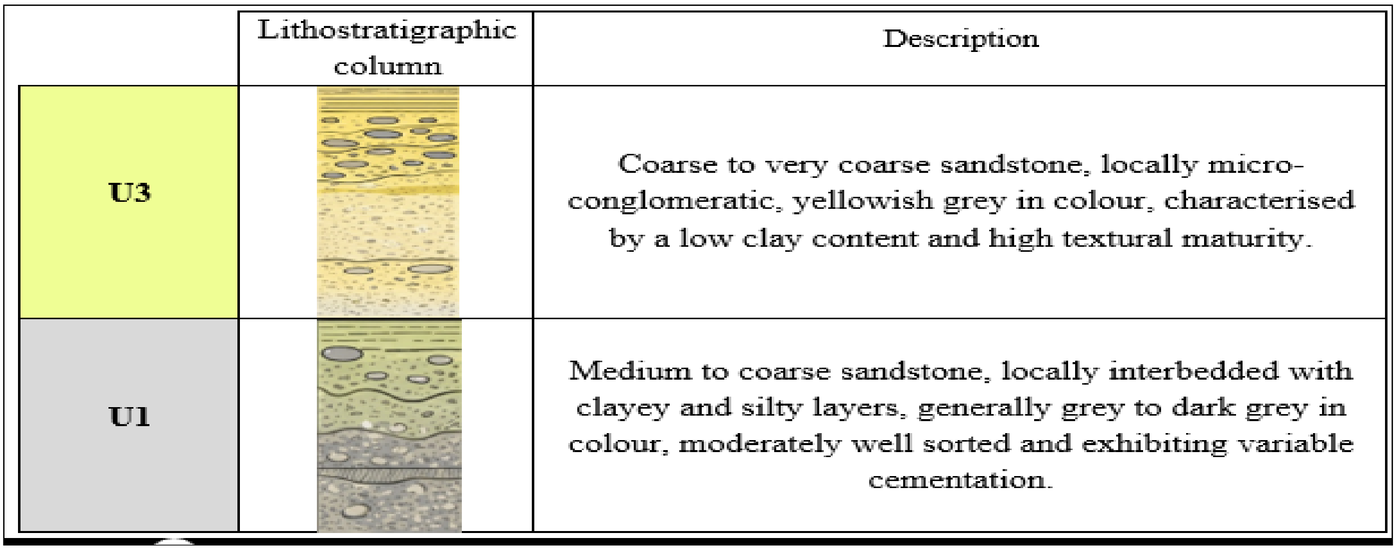


Fig 2 TAM-2573 Survey and Associated Lithostratigraphic
Series: Red Series (Red = Izégouande); Grey Series (Green = Arlit Unit; Grey = Tarat (SL); Black = Tchinézogue) ([7]).



	Lithostratigraphic column	Description
U3		Coarse to very coarse sandstone, locally micro-conglomeratic, yellowish grey in colour, characterised by a low clay content and high textural maturity.
U1		Medium to coarse sandstone, locally interbedded with clayey and silty layers, generally grey to dark grey in colour, moderately well sorted and exhibiting variable cementation.

Fig 1 Map Showing the Geographical Location of the Town of Arlit
(Geographical Division of the Archives Directorate of the Ministry of Foreign Affairs, 2004, modified by [7]).

➢ *Diagraphic Signatures*

The data presented in ''Fig. 4'' correspond to the diagraphic responses from the TAM-2573 survey in the Tamgak South sector. The recordings are represented in the form of curves divided into several columns: column A groups together the spontaneous polarisation (SP) and resistivity curves, column B illustrates the natural radioactivity (gamma) curve, column C corresponds to the caliper, while column D presents the curve relating to the verticality of the borehole.

Joint analysis of the diagraphic responses from the TAM-2573 survey makes it possible to characterise the lithology of the formations traversed and to specify the lithological boundaries between the different stratigraphic units. The contrasts observed on the resistivity and radioactivity curves are reliable indicators of the nature of the materials and lithological transitions.

Within the Tarat formation, the diagraphic responses indicate a predominance of sandstone facies, with internal variations allowing two lithological units to be distinguished. Unit U3 is characterised by high resistivity and low radioactivity, consistent with coarse to very coarse sandstones with a low clay matrix content. Conversely, unit U1 has more

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26jan499

moderate resistivity values associated with significantly higher radioactivity, reflecting medium to coarse sandstones that are more clayey and locally enriched in organic matter.

The lithological boundary between units U3 and U1 is marked by an abrupt contrast in diagraphic signatures, reflected in a decrease in resistivity and a concomitant increase in radioactivity. This contrast indicates a clear change in sedimentation conditions and deposit nature, confirming the validity of the intra-Tarat division established from subsurface data.

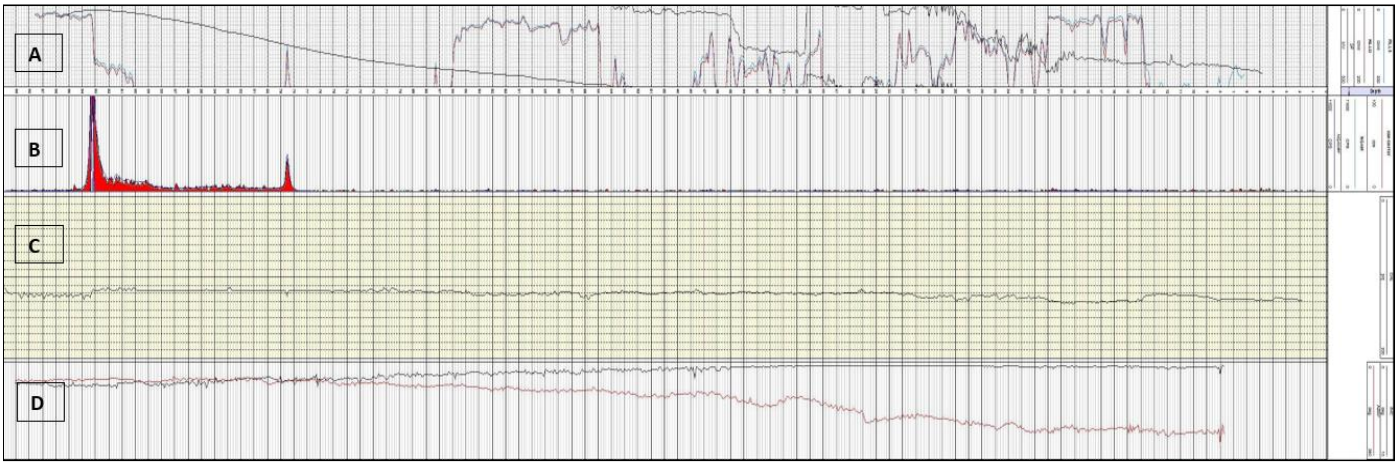


Fig 4 Diagraphic Responses from the TAM-2573 Survey on South Tamgak: Spontaneous Polarisation or SP and Resistivity (Column A), Radioactivity (Column B), Caliper (Column C) and Verticality (Column D) ([7]).

- *Geological Sections and Structural Control of Tarat Sedimentation in the Tamgak South Sector*

The different lithological units identified in each Tamgak South borehole were correlated with each other in order to establish reliable stratigraphic correspondences, enabling the reconstruction and representation of geological cross-sections ''Figs 5, 6 and 7''.

Fig. 8 shows the location of the cross-sections of figures 5, 6 and 7 in the study area.

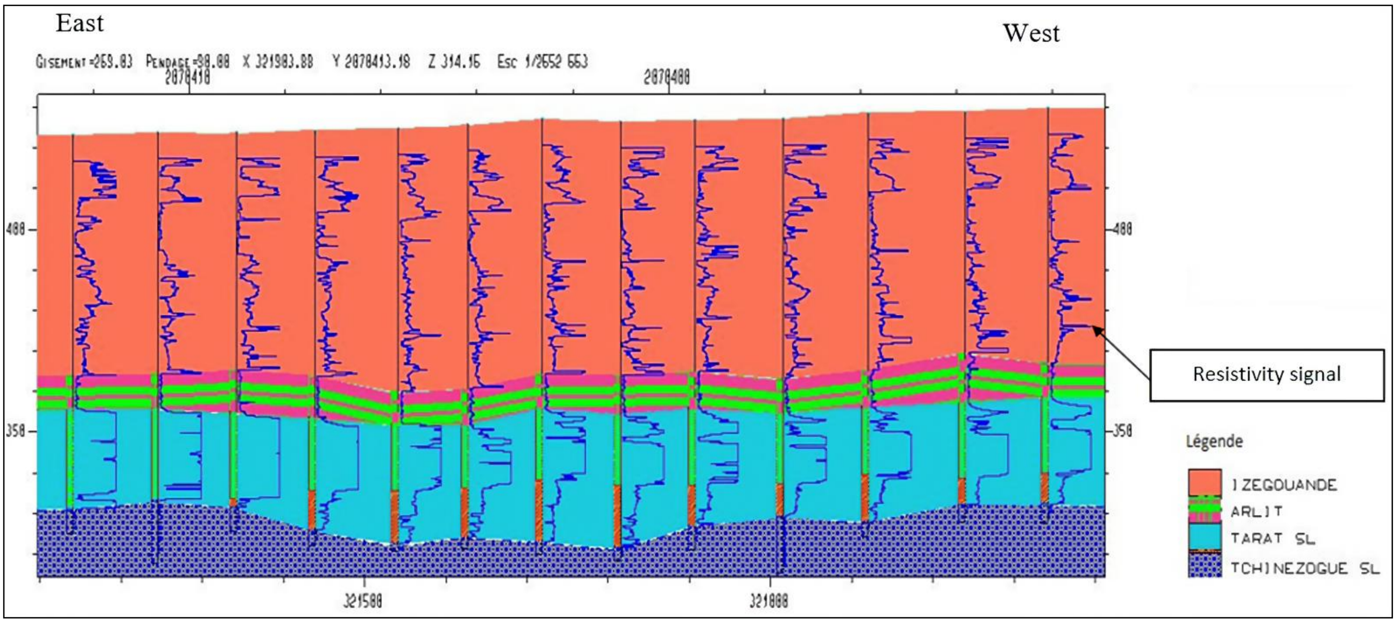


Fig 5 East-West Cross-Section of Sermine and Lithostratigraphic Correlation of the Tamgak South Sector ([7]).

Analysis of the west–east section ''Fig. 6'' of the Tamgak South sector reveals a gradual thickening of the Tarat formation towards the central part of the sector, as well as a marked bevelling of unit U1 towards the east. This stratigraphic geometry is directly controlled by the presence of the Taoussa dome, located to the east of the study area. The thickening of the Tarat occurs mainly at the base of the western flank of the Taoussa dome ''A in Fig. 6'', while the bevelling of unit U1 is observed on the same flank ''B in Fig. 6'', reflecting a major structural influence on sedimentation.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26jan499

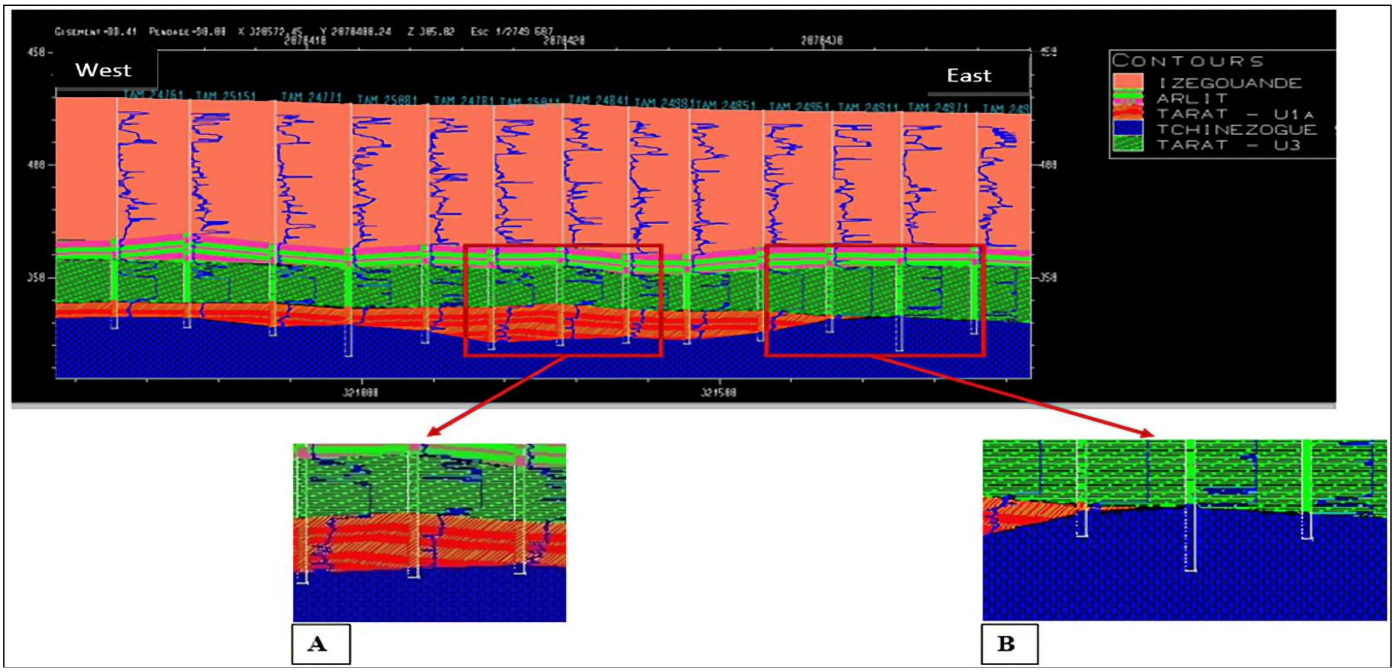


Fig 6 West-East Cross-Section of Tamgak Sud;
A: Thickening Zone of the Tarat; B: Beveling Zone of Unit 1 ([7]).

The north-south section ‘’Fig. 7’’ of the Tamgak South sector shows an opposite variation in the thicknesses of units U1 and U3. Unit U1, in the vicinity of Tchinézogue, shows a gradual thinning towards the north ‘’A in Fig. 7’’ and a thickening towards the south ‘’B in Fig. 7’’, while unit U3 shows the opposite trend, with a thinning towards the south and a thickening towards the north. This stratigraphic organisation is interpreted as the result of the influence of a Tchinézogue morphostructural high located to the north of the sector. According to [8], this Tchinézogue high is associated with a significant reduction in the thickness of the Tarat Formation sandstones, confirming its major role in controlling sedimentation.

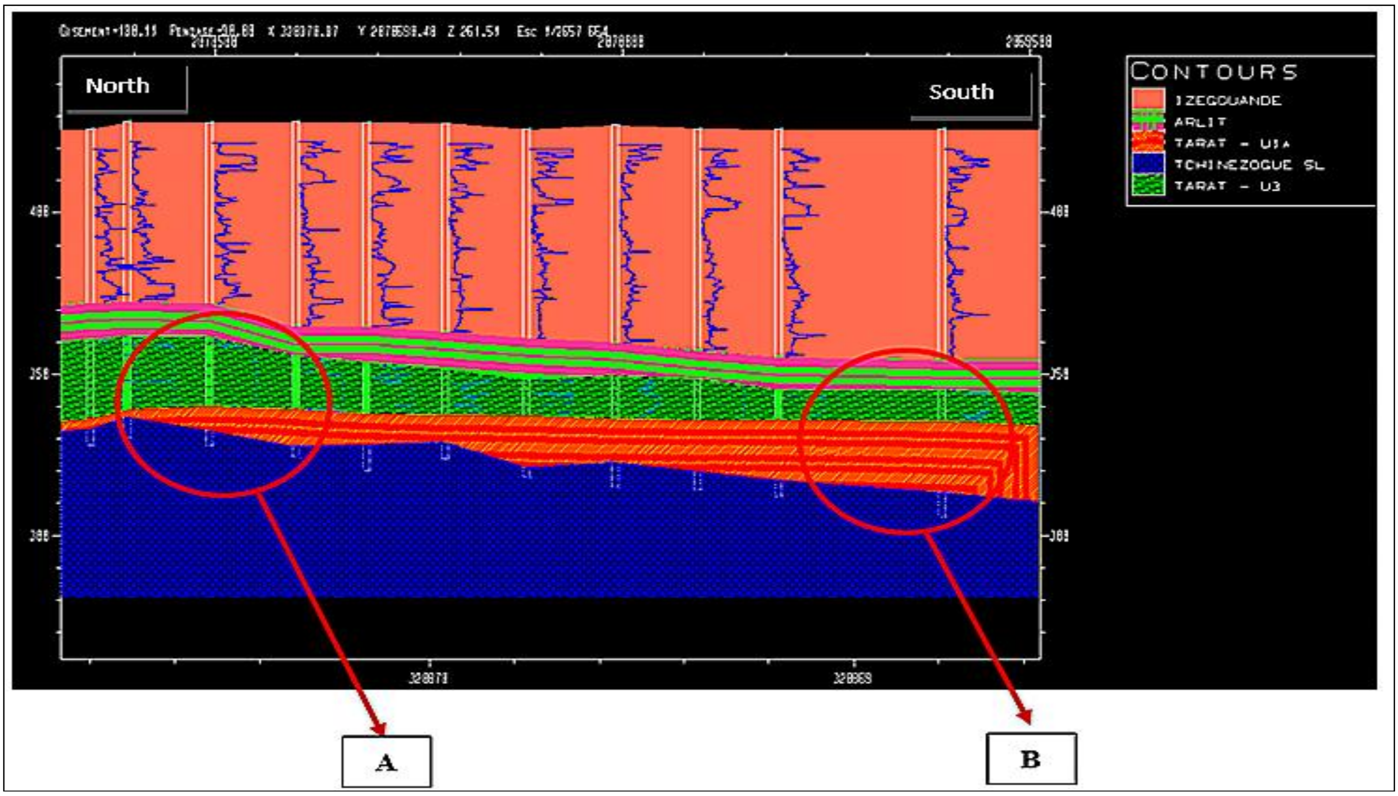


Fig 7 North-South Cross-Section of Tamgak South; (A): Thickening of Unit 3; (B): Thickening of Unit 1 ([7])

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26jan499

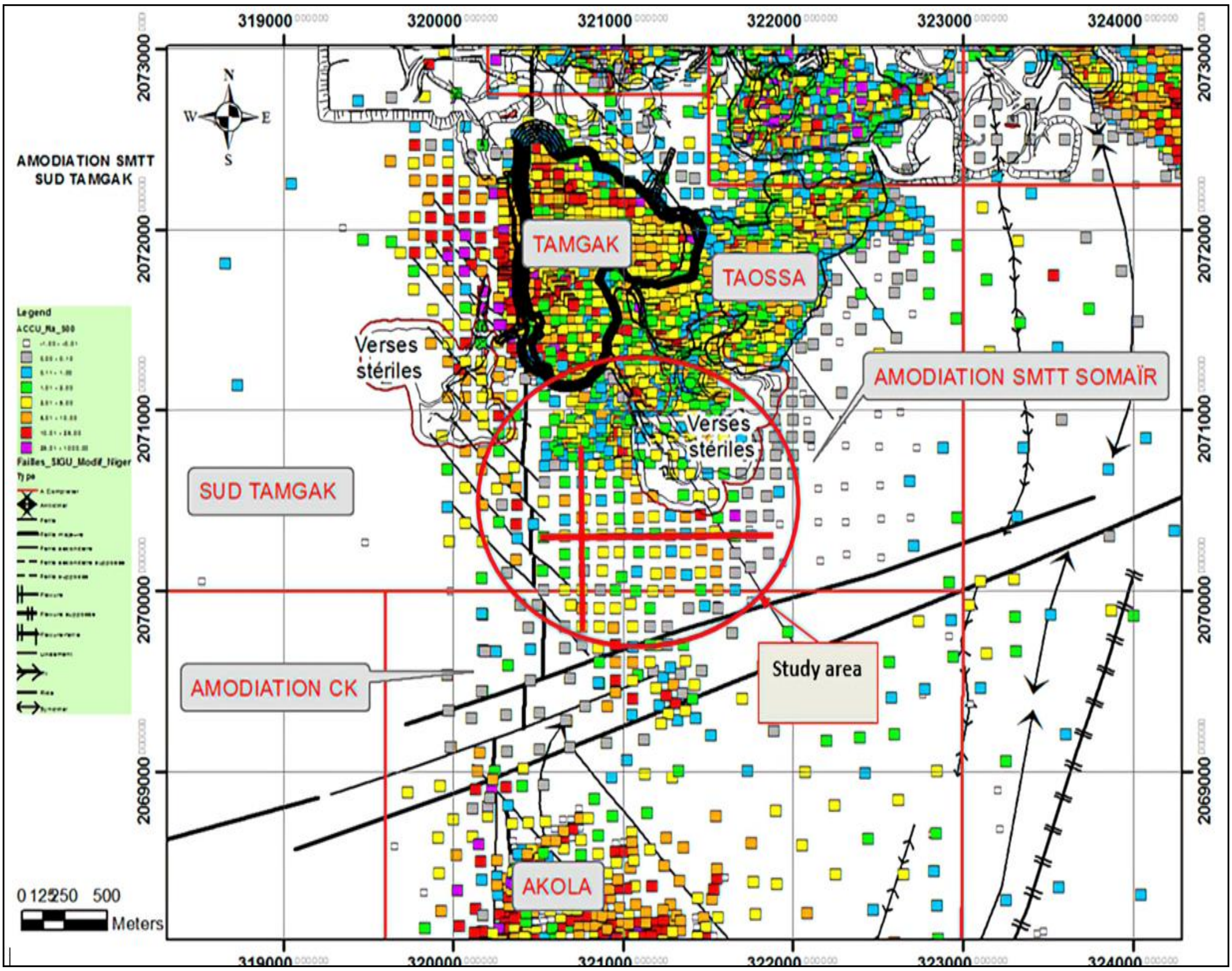


Fig 8 Map Showing the Location of the Cross-Section's Lines in the Study Area. ([7])

IV. DISCUSSION

➢ *Tectono-Sedimentary Control of the Tarat Formation*

The lateral thickness variations, stratigraphic truncations and simplified intra-Tarat architecture observed in the Tamgak South sector indicate that sedimentation of the Tarat Formation was not spatially uniform but occurred under conditions of differential accommodation. These geometries are interpreted as reflecting a significant tectono-sedimentary control during Carboniferous deposition.

The west–east and north–south cross-sections reveal systematic relationships between thickness variations of units U1 and U3 and the position of morphostructural highs such as the Taoussa dome and the Tchinézogue high. These structures appear to have locally reduced accommodation space, leading to thinning, stratigraphic truncation and, in some cases, non-deposition of certain intra-Tarat units. Similar relationships between basement relief, synsedimentary tectonics and sandstone architecture have been described elsewhere in the Tim Mersoï Basin ([9]; [10]; [8]).

The structural framework of the Arlit district is dominated by inherited Pan-African faults-oriented N-S, N30°E, and N70°E, which have been reactivated several times during post-Pan-African tectonic phases ([9]; [11]; [12]). The observed geometries are consistent with a scenario in which subtle synsedimentary reactivation of these structures may have generated local deposition centers and structural highs, controlling sediment thickness, facies distribution, and internal stratigraphic architecture.

Although the interpretation favours a synsedimentary tectonic control, alternative processes such as differential compaction, post-depositional erosion or minor tectonic inversion cannot be entirely excluded. However, the systematic spatial correspondence between thickness variations and mapped structural elements strongly supports a primary tectonic influence on sedimentation patterns.

➢ *Role of Inherited Structures in Stratigraphic Architecture*

The influence of inherited basement structures on the sedimentary architecture of intracratonic basins is widely recognised. In the Tim Mersoï Basin, reactivation of Pan-African fault systems has been shown to exert a first-order control on basin geometry, subsidence patterns and sediment distribution ([10]; [12]; [13]).

In the Tamgak South sector, the Taoussa dome and the Tchinézogue high are interpreted as long-lived morphostructural features that were intermittently active during Carboniferous sedimentation. Their influence resulted in the development of local accommodation contrasts, producing zones of enhanced sediment accumulation adjacent to zones of thinning or truncation. This structural segmentation likely controlled the spatial organisation of depositional environments, the stacking patterns of fluvial to fluvio-deltaic sand bodies and the distribution of finer-grained intervals.

The inverse relationship observed between the thickness of units U1 and U3 along the north-south profile suggests a dynamic equilibrium between sediment supply and accommodation, probably controlled by the relative activity of these structural elements. This behavior would be consistent with tectonically influenced sedimentation in intracratonic environments, where low-amplitude but persistent structural movements can strongly influence stratigraphic architecture over long time scales.

➢ *Implications for Uranium Mineralization*

The tectono-sedimentary framework has important implications for the development of sandstone-hosted uranium deposits. Structural controls on sedimentation directly influence reservoir architecture, connectivity of permeable sand bodies, distribution of clay-rich seals and the localisation of redox fronts, which are critical factors for uranium precipitation ([13];[2]; [6]).

In the Tamgak South sector, the direct superposition of unit U3 on unit U1, combined with the proximity of structural discontinuities, is interpreted as having favoured fluid circulation and the development of redox interfaces conducive to uranium mineralisation. Although no direct mineralisation data are presented here, the observed stratigraphic and structural configuration is consistent with genetic models proposed for the Arlit district, in which uranium deposition is associated with permeability contrasts and structural conduits for oxidised mineralising fluids ([9]; [12]; [13]).

These observations suggest that careful integration of stratigraphic architecture and structural analysis is essential for identifying favourable exploration targets in the Tim Mersoï Basin and similar intracratonic sandstone basins.

V. CONCLUSION

This study highlights the fundamental role of tectono-sedimentary processes in controlling the stratigraphic architecture of the Tarat Formation in the southern Tamgak sector. The observed lateral variations in thickness, stratigraphic truncations, and simplified intra-Tarat organization reflect differential accommodation controlled by the reactivation of inherited basement structures.

Morphostructural highs such as the Taoussa dome and the Tchinézogue high are thought to have exerted a major influence on sedimentation patterns, producing areas of thinning, truncation, and reduced accommodation adjacent to local depocenters. These geometries are interpreted as resulting mainly from subtle but persistent synsedimentary tectonic activity along the N-S, N30°E, and N70°E oriented Pan-African fault systems.

The stratigraphic configuration, characterised by the superposition of coarse-grained unit U3 over finer-grained unit U1 and by strong lateral variations in thickness, likely played a significant role in controlling reservoir architecture, fluid flow pathways and the localisation of redox interfaces. As such, it may have contributed to the development of favourable conditions for sandstone-hosted uranium mineralisation, consistent with existing genetic models for the Arlit district.

The Tamgak South sector thus provides a representative example of how inherited structural frameworks can exert a long-term control on sedimentation and ore-forming processes in intracratonic basins. These results emphasise the importance of integrating structural, stratigraphic and sedimentological data in both academic studies and mineral exploration strategies in the Tim Mersoï Basin and comparable geological settings.

ACKNOWLEDGMENT

The authors would like to thank SOMAÏR for providing access to the geological and geophysical data used in this work, as well as Abdou Moumouni University of Niamey for the academic and scientific supervision provided in the context of the Master II thesis from which this manuscript originated.

This manuscript was written in French, and the English translation was done by Deepl software.

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ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26jan499

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