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RESEARCH ARTICLE

INFLUENCE OF TECTONICS ON THE CIRCULATION OF MINERALIZED FLUIDS IN THE EBBA SOUTH ARLIT SECTOR (NIGER)

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Abstract

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The present work investigated tectonics' effects on the circulation of mineralizing fluids in the south Ebba sector. The study of the wells, the evaluation of the indices, the observation of the fronts and facings, as well as the calculation method and the presentation of the indices made it possible to obtain the following results: Maps of the distribution of the values of the organic matter, pyrite, carbonates and oxyhydroxides parameters within the Ebba Sud sector. The maps of the different parameters permitted, on the one hand, to better distinguish the redox aspect of the Ebba south sector and, on the other hand, to highlight the redox front.All results show that the west is less oxidized within the Ebba Sud sector and the east is more oxidized. The interface between these two parts corresponds to the redox front where most of the mineralization is concentrated. The latter was formed by the redox mechanism associated with meteoric fluid circulation with predominant structural control. The structures that have contributed to fluid transmission are brittle accidents, in particular, bend No. 30 and the rheology of the surrounding formation, by exercising control at the scale of the mining sector.

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Introduction:-

Between 1959 and 1967, Niger experienced a phase of intensive uranium exploration, which led to the discovery and exploitation of the Arlit (exploited by Somaïr since 1969) and Akokan (exploited by Cominak since 1974). In Cominak, exploitation began with the Akola deposit, then with Akouta, and finally with the Ebba deposit [1]. The latter is divided into two sectors, the northern sector and the southern sector, which belong to the Guézouman formation.

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All of these deposits known in their sectors are located in Arlit (Agadez region) and lie in sandstone sedimentary formations from the Upper Carboniferous[2]. However, the behavior of uranium in the sediment is closely related to the oxidation-reduction conditions of the medium [3, 4]. Being a sediment, special attention must be paid to the study of redox parameters (organics, sulfides, carbonates, and oxyhydroxides) associated with the circulation of fluids to understand the mobility and fate of uranium in the geological environments of the Ebba-Sud sector, which is the target for exploration and mining.

The difference in rheology allows the formation of large fracture zones and the creation of pressure conditions for suppralithologicfluids [5-8]. The passage of the mineralizing fluid is controlled by the rheology of the surrounding formation and the accidents, especially the brittle ones, identified by [9-12]. The mechanism of fluid transfer at the origin of the uranium mineralization concentration in the Ebba-Sud sector is poorly understood.

Therefore, this article aims to study the origin of mineralizing fluids as well as the structural ones that contributed to the transfers of mineralizing fluids in the south Ebba sector.

Materials and Methods:-

Sampling

The database used consists of 516 holes drilled in the Ebba Sud sector. Together with Ebène, it constitutes the PexAfasto, located south of Akouta (between18 ° 43 'N and 7 ° 20'E)(Figure 1).

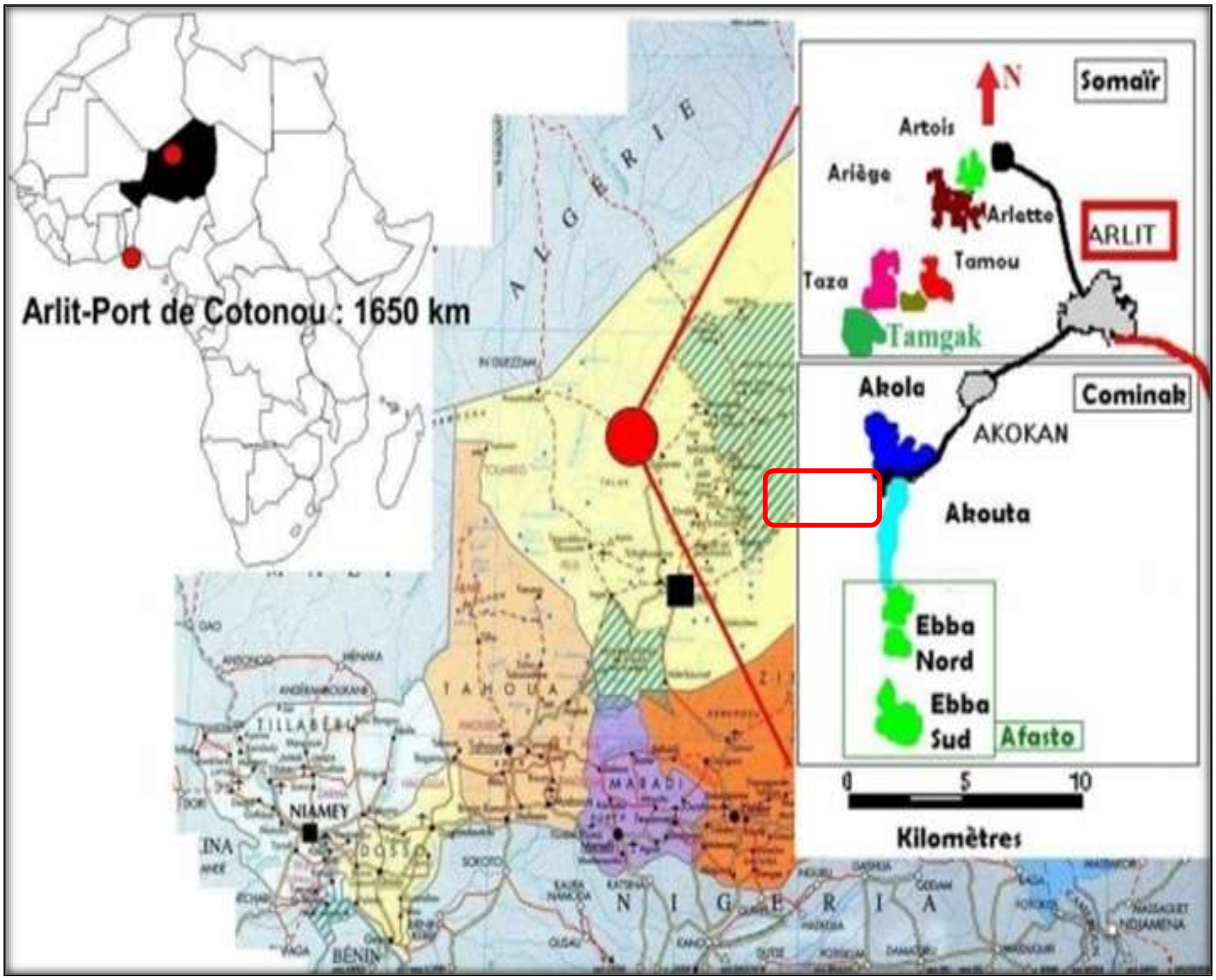

Figure 1:- Location of sampling site.

Experiments

When the cuttings are surveyed, each redox parameter (organic matter, sulfides, carbonates and oxyhydroxides) is assigned an index whose value varies from 0 to 3 for the "organic matter, sulfides and oxyhydroxides" parameters and from 0 to 2 for the “carbonates” parameters. These values represent the evaluation codes for the parameter in the dictionary of the WEllCAD and SERMINE software for processing survey data.

The method for calculating the accumulation of a given index for a formation under consideration and for each sounding is the same for all redox parameters. This method is a weighted average of the different redox parameters and is calculated as follows:

$$\mathbf{Iguez} = \Sigma \frac{(\mathbf{Ipguez} \times \mathbf{Pp})}{\mathbf{Pguez}} \quad \textbf{Eqn. 1}$$

Where Iguez = index of Guézouman, Ipguez = index of Guézouman's pass, Pp = power of the pass, Pguez = power of Guézouman.

The calculated index represents a global accumulation of the parameter in Ebba Sud or Guézouman in the broad sense.

Results and Discussion:-

Organicmatterparameterevaluation

The presence of organic material is significant in the Ebba Sud sector (Figure 2). Strong accumulations of organic matter were observed in the western part. They move from the center to the southeast. Weak accumulations are found in the eastern part. The places rich in organic matter are reduced environments. These results are confirmed by the findings of [13, 14, 15], who also studied organic matter richness and its role as a reductant in Guézouman. The organic matter parameter is a good indicator of the circulation of fluids [11, 16].

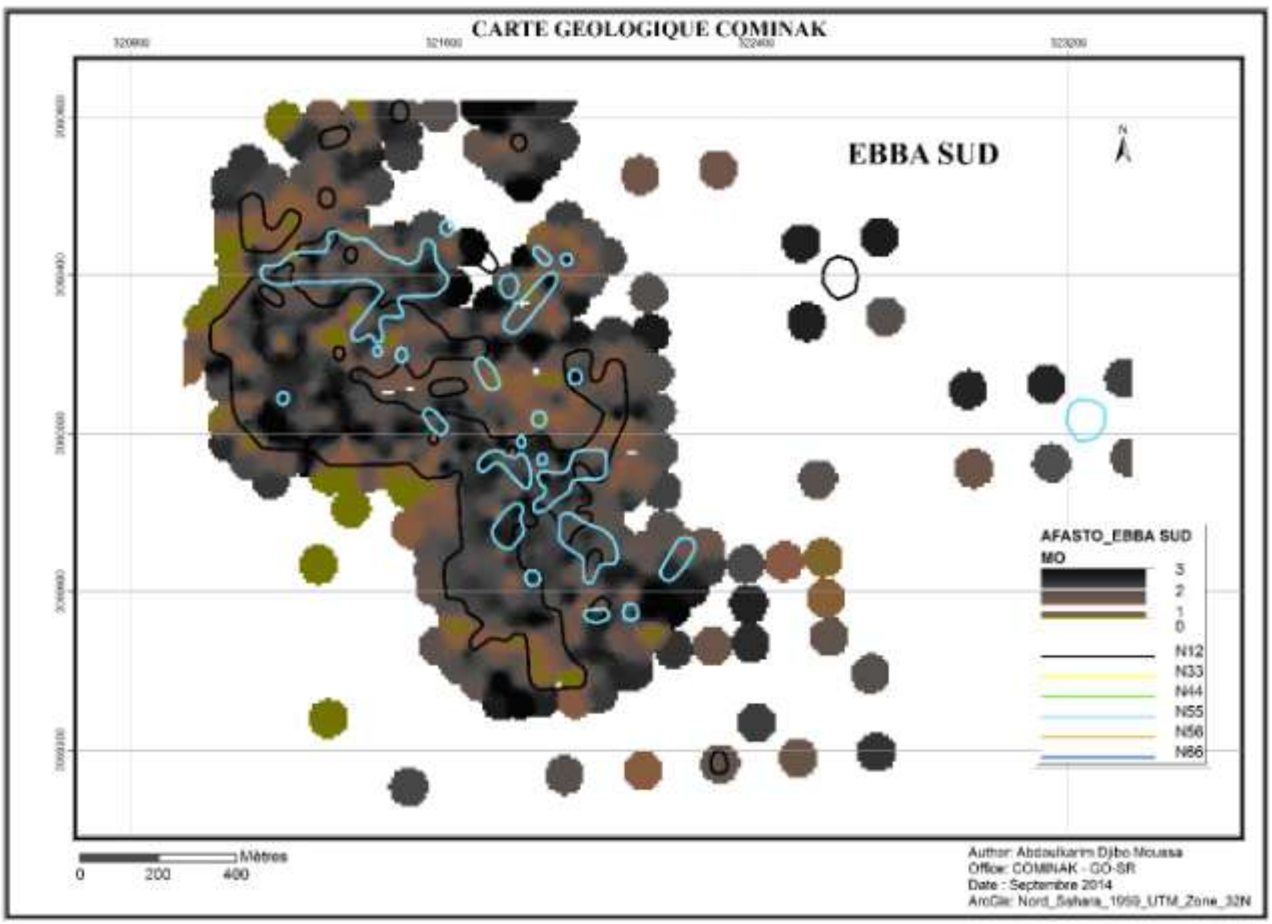

Figure 2:- Distribution of the values of the organic matter parameter in Ebba Sud.

Pyrite parameterevaluation

Pyrite (Figure 3)is strongly enriched in the western part and moderately enriched in the center, north and south. In the eastern part, the weak enrichments are mainly outside the mineralized contours. Just like the organic matter, the distribution of pyrite appears to be oriented along the axis (north-west/south-east) and also follows the mineralized contour. Organic matter and pyrite go hand in hand and always play the role of reducing agents for uranium. These results are consistent with those of [1, 16, 18, 19].

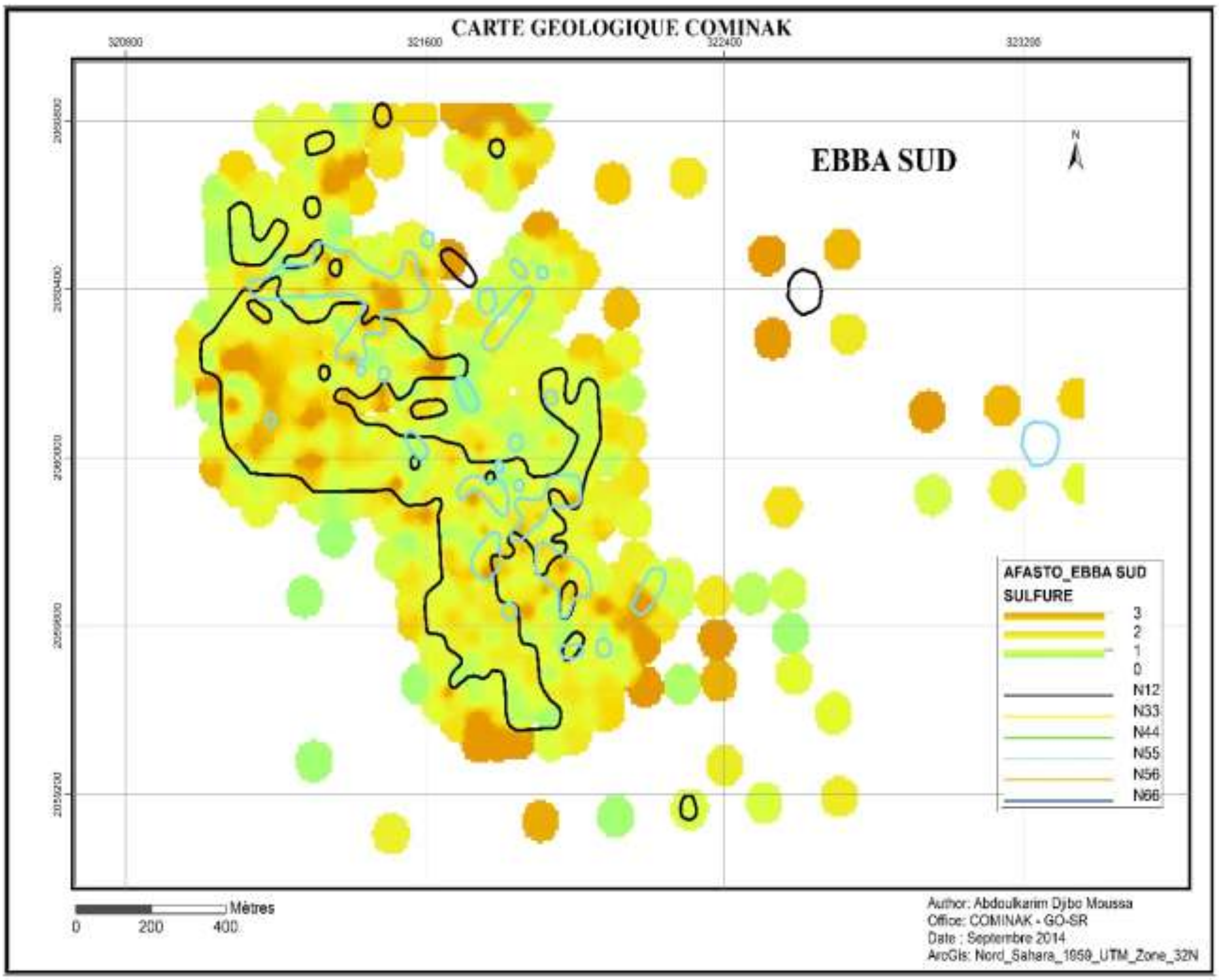

Figure 3:- Distribution of the values of the pyrite parameter in the Ebba Sud sector.

Carbonate parameterevaluation

Figure 4 shows that the carbonate parameter is present everywhere in the study area, with the exception of the western part. However, the strong values of the index (1-2) are much more frequent in the eastern part and in the southeast. This distribution of the carbonate parameter simultaneously follows the NW/SE and EW axes. Carbonates are an expression of preferential fluid circulation in fault zones [11, 16]. The presence of carbonates in almost the entire study area shows on the one hand the re-formation of carbonates during diagenesis and on the other hand the circulation of fluids transporting uranium oxide [1] has shown that the mineral re-formations caused by the evolution of organic matter continue with the crystallization of carbonates once all the sulfur has been fixed in the form of sulfides (e.g. in black argillites, iron dolomite, ankerite and siderite). Indeed, the reactions of destruction of organic matter generally release HCO3- ions.[1], therefore carbonates are solid compounds containing the carbonate ion CO_3^{2-} and are derived from carbonic acid.

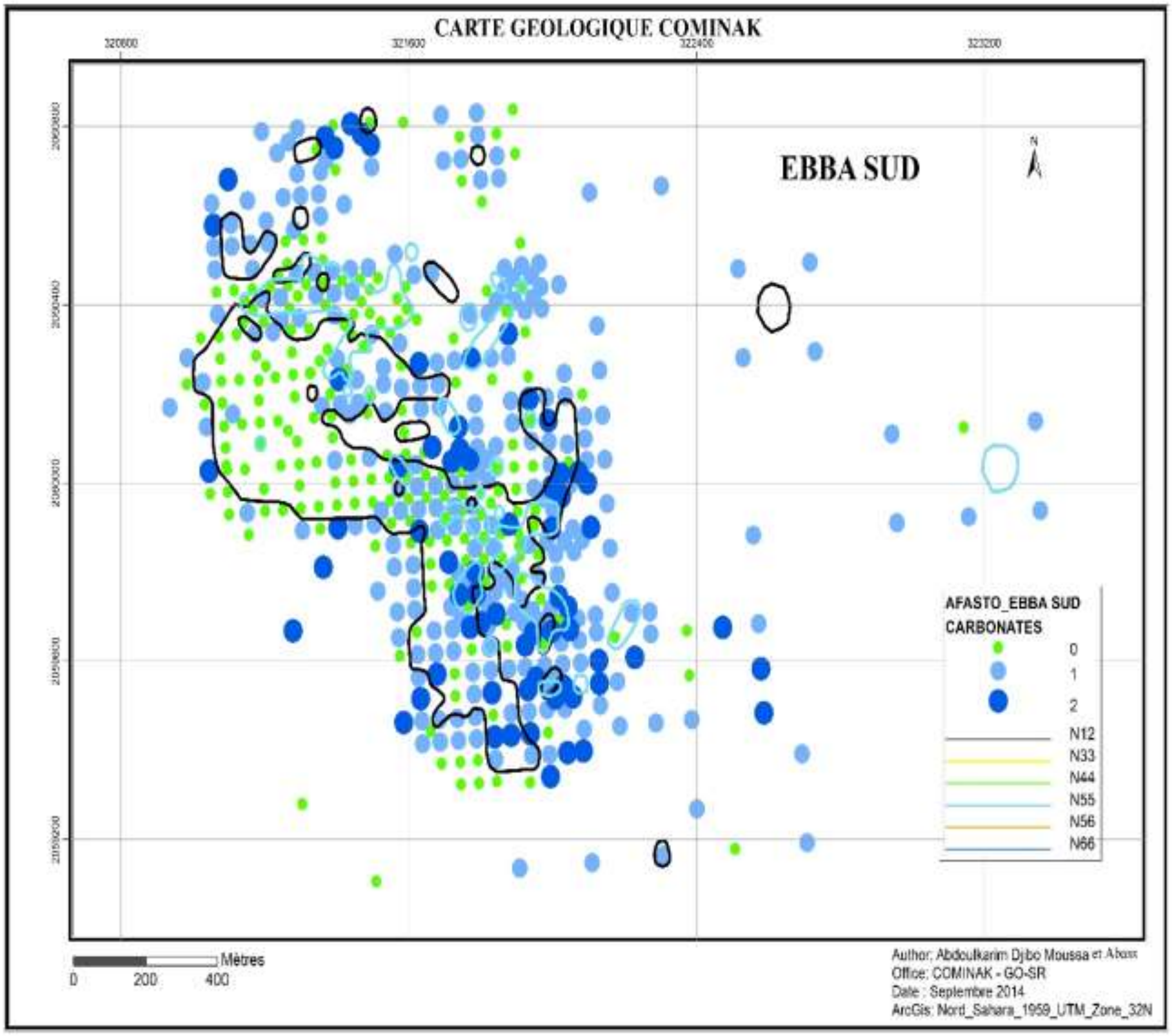

Figure 4:-Distribution of the values of the carbonate parameter in the Ebba Sud sector.

Oxy-hydroxideparameterevaluation

Outside the western part (Figure 5), the oxygen-hydroxide parameters show values greater than zero (0) in the entire sector. The highest values are found in the center and in the other parts. Like the carbonates, the oxyhydroxides are also distributed in the NW-SE and EW directions. We therefore observe a distribution of oxyhydroxide parameters that overlaps with that of the carbonates. They play almost the same role in the geochemistry of uranium; they are good indicators of the circulation of the fluids. This ideaisshared by [11, 16].

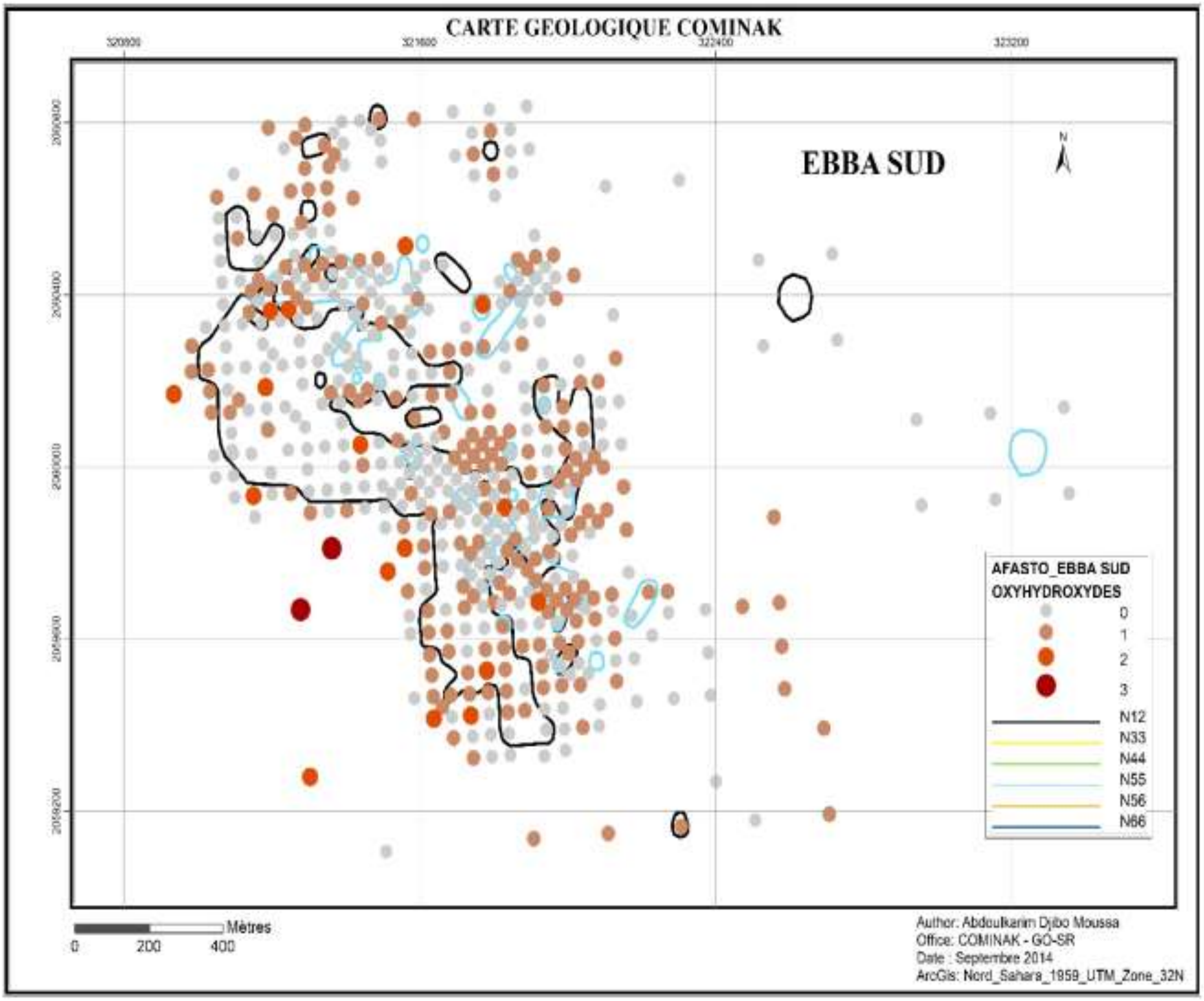

Figure 5:-Distribution of the values of the oxy-hydroxide parameter in Ebba Sud.

Oxidation-reduction and accumulation of Uranium within the Ebba Sud sector

Figure 6 shows a combination of parameters for organic matter and oxyhydroxide to better understand the redox aspect of the study area. The redox aspect of the study area is indeed well separated, the east is oxidized and the west is practically reduced. The interface between these two parts corresponds to the redox front that separates the reduced formations in the west from the oxidized ones in the east. Most of the mineralization is concentrated at this interface. Oxyhydroxides are good indicators of the oxidation of a medium [18, 20, 21]. The parameters of organic matter and oxyhydroxides made it possible to identify the redox front that played a role in the formation of the Ebba-Sud mineralization. According to [15], the front phenomenon also exists in the south, where it is strongly oriented due to the bending of the AZAWA. The front has been traced in the central part of the Ebba sector, with the reduced formations in the west being bounded by the oxidized ones in the east.

Oxidation pockets in a reduced assembly also characterize the area between these two sides. Most of the mineralization is concentrated at this interface and forms the oxidation-reduction front. The radiometric potential is higher in the strongly reduced zones and in the contact zones (redox front). In strongly oxidized areas, on the other hand, it is zero. It should be noted that the strong uranium enrichments (purple color) from the Ebba Sud sector are most frequently observed at the redox front(Figure 7).

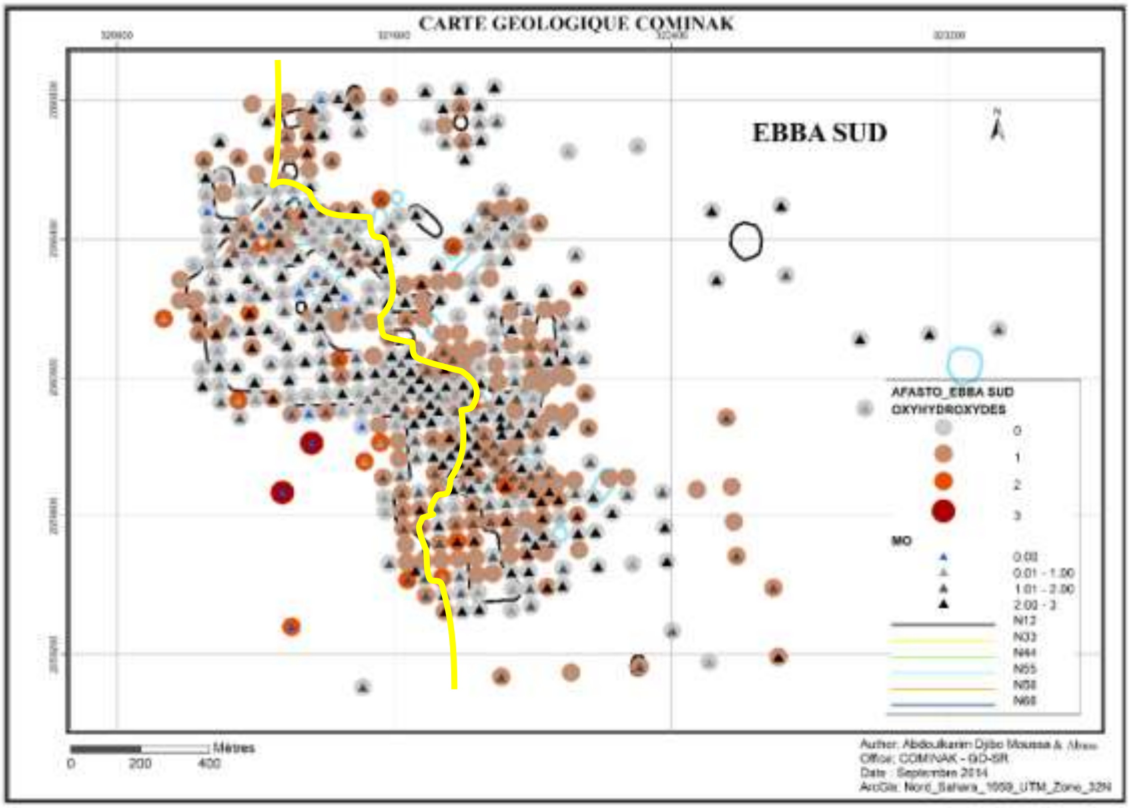

Figure 6:-Map showing the redox front in South Ebba.

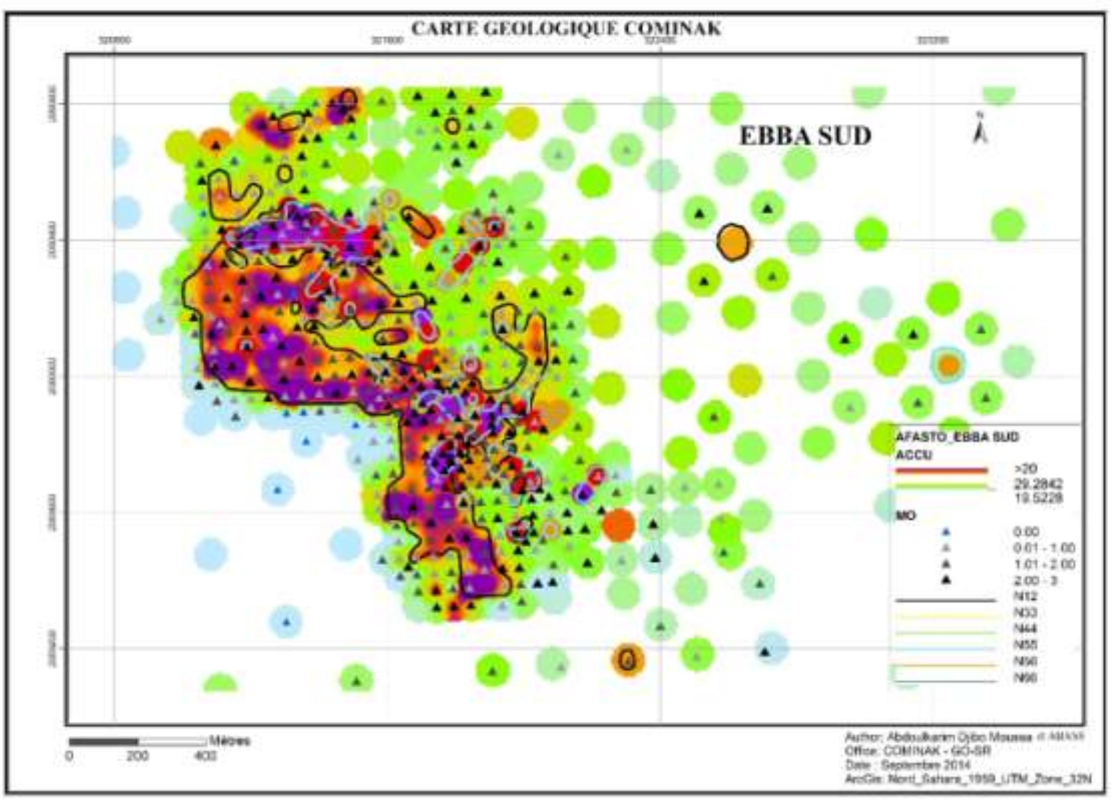

Figure 7:-Map showing the accumulation of Uranium in South Ebba.

Influence of tectonics on the circulation of mineralizing fluids within Ebba

The presence of the redox front proves that there is a circulation of fluids in the Ebba sector (Figure 6). The fluids would therefore flow from northeast to southwest (Figure 8) and be channeled by faults, fractures or the porosity of the host formation. Three directions of fluid circulation were proposed in this study. The first is NE-SW, which corresponds to the direction of brittle accidentsN30 ° [11]. Also, this author claims that steering accidents N30 °influence the location and general structuring of deposits throughout the mining sector. The second is EW and corresponds to the direction of a secondary channel resulting from the bifurcation of the main channels [22]. Finally, the third is NS, which corresponds to the direction of the arlite fault. This contribution to fluid circulation is not directly noticeable at the sector level, but at the regional level, as shown by [11].

The author confirms that the accident at Arlit NS is the main metallotect controlling the distribution of deposits at the regional level (deposits in the Arlit and Imourarène sectors).

Given the context in which the deposit is located in the Ebba sector and given the mechanism by which it was formed, this fluid appears to have a meteoric origin. the authors of the study [23]hold the same view or claim that the original fluids for the formation of mineralization fronts in all redox front type deposits are of meteoritic origin. In Ebba Sud, we can say that there is a remobilization of uranium mineralization by oxidizing meteoritic fluids that generate concentrations at the level of the secondary fault compared to the arlite fault, as demonstrated by [18]in the Akouta deposit. The Arlite Fault could therefore play an important role in the circulation of mineralizing fluids at the regional scale.

At this level, it is possible to consider a circulation from the west inflection (oxidized) to the east inflection (reduced), as shown by [15]. According to the same author, these circulations from west to east were the origin of the mineralization of the Guézouman Formation. This proves that large-scale fluid circulation took place in the deformation zones associated with the arlite fault and the large-scale drainage function of this structure[24]. The uranium mineralization therefore tends to indicate a remobilization of metals and a concentration of hydrothermal fluids within the lithology of the host rocks with a predominant structural control [25].

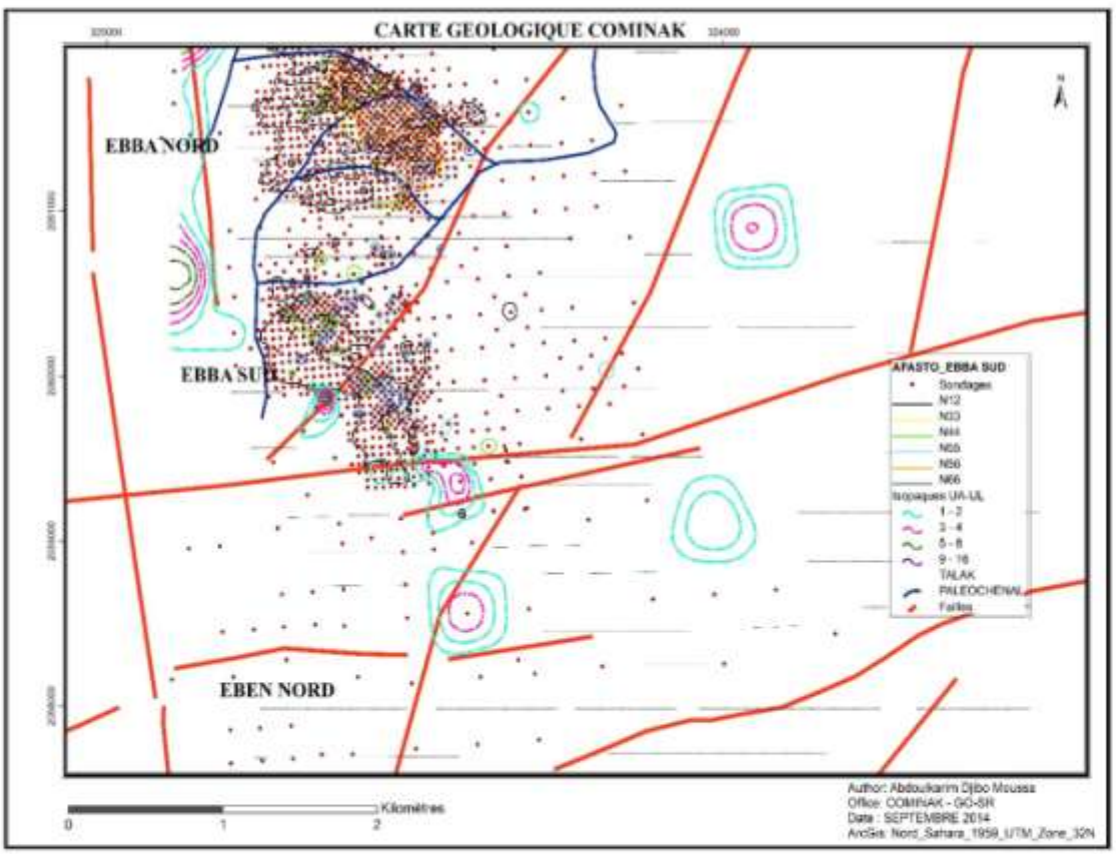

Figure 8:-Map showing the effect of tectonics on fluid circulation in South Ebba.

Conclusion:-

In the Ebba sector, the redox parameters are poorly distributed in time and space. However, a coupled distribution of the parameters was always observed. The analysis of the various redox maps revealed that the mineralization of Ebba South is associated with organic material, sulfides, and carbonates. Pyrite and organic material are found in reduced areas. In the study area, places rich in organic matter are therefore reduced environments, as they have been used more for the storage and accumulation of uranium. The presence of carbonates, both in the reduced and oxidized medium, testifies on the one hand to the formation of new minerals during the evolution of the organic matter and on the other hand to the circulation of the fluid that transports the gold and uranium oxide. Most of the Ebba Sud mineralization was established by the redox mechanism coupled with the circulation of fluid meteoric with predominant structural control.

The structures that have contributed to the transfer of fluid include accidents N ° 30 and secondary faults through the exercise of control at the scale of the mining sector. Nevertheless, we can underline a control at the scale of the region led by the Arlit fault. Finally, the channels, the fractures, and the porosity of the sandstones of the formation undoubtedly contribute to the transmission of mineralizing fluids in the Ebba South sector.

Author Contributions:-

All authors contributed to the success of this present research. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement:-

The data presented in this study are available on request from the authors.

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Conflicts of Interest

The authors declare no conflict of interest.

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