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Proposal of a dewatering system for uranium mineralization in the Tim Mersoï basin in Arlit region (North Niger): Case of the Apophyse Ariège deposit

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ABSTRACT: The Tarat aquifer provides water for the population (AEP) of the city of Arlit and Akokan, as well as for industrial water needs (AEI). However, in the mines, water can be an obstacle to mining. This study aims to contribute to a better understanding of the hydrodynamic functioning of the Tarat aquifer in order to design a dewatering device. A methodological approach focusing on the piezometric study and the mapping of hydrodynamic parameters allowed to highlight that the uranium mineralizations are below the piezometric level in the western, northern and central parts. The latter require dewatering, hence the installation of a system comprising three boreholes.

KEYWORDS: Hydrogeology, Dewatering, Hydrodynamics, Tarat aquifer, Niger.

1 INTRODUCTION

The western edge of the Aïr massif is a semi-arid region. Despite the scarcity of surface water, the locality of Arlit has considerable underground water resources and contains important uranium deposits. This uranium potential has been developed since the late 1970s by two companies: SOMAÏR (1969) and COMINAK (1976). The exploitation of this uranium resource has been accompanied by excessive pumping of the Tarat aquifer. In mines, although water is used in mining activities (dust suppression, ore processing), it can be a hindrance to mining operations ([1], [2]). The Tarat, an aquifer geological formation, also contains the mineralization. Thus, some deposits, such as the Ariège apophyse deposit, are below the static level of the piezometric level, hence the need to dewater the deposit. The main objective of the present study is to understand the hydrodynamic functioning of the Tarat aquifer in order to set up a dewatering device.

2 LOCATION OF THE STUDY AREA

The Arlit region is located in the North East of Niger, more precisely between longitudes 7°15' and 7°30' East and latitudes 18°15' and 19°00' North, with an average altitude of 400 m, limited to the East by the crystalline basement of the Aïr massif. (Fig.1). This region receives an average annual rainfall ranging from 120 mm in the Aïr massif (1000-2022 m altitude) to 40 mm in the plains [3], with an average annual evaporation of about 4100 mm [4].

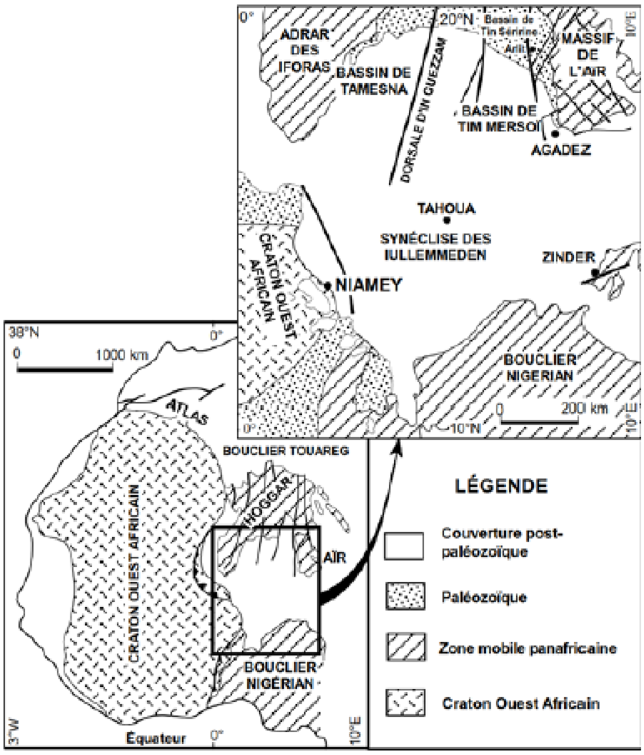

Fig. 1. Location of the Tim Mersoi basin in the Iullemmeden syneclise [5], [6]

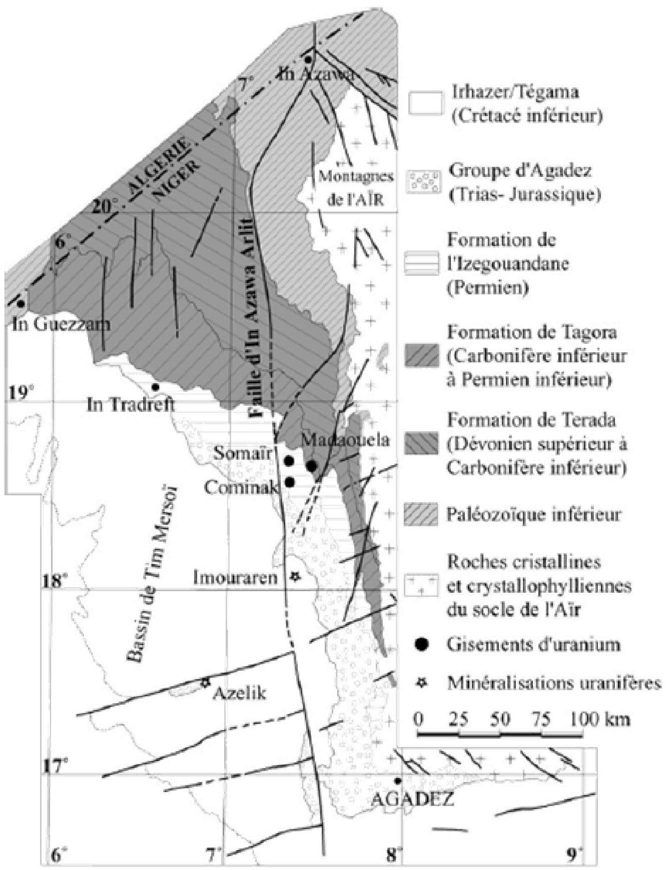

Fig. 2. Geological map of the Tim Mersoï basin along the western edge of the Aïr Massif [7]

3 Geological Environment Of The Study Area

The Tim Mersoï basin is the northeastern extension of the Iullemmeden synclise ([5], [8], [9], [10], [7]). It is limited to the east by the Aïr massif, to the north by the Hoggar massif, and to the west by the In Guezzam ridge. It extends into Algeria where it is called the Tin Serririne basin [11]. (Fig. 1). The oldest sedimentary series are of Cambro-Ordovician age [12], and part of the basin contains a sedimentary cover with ages ranging from Devonian (Teraghy sandstone) to Lower Cretaceous (Tegama Group). Four major families of faults are recognized in the Tim Mersoi basin. These are the N0° fault system known as the Arlit fault, the N30° fault system of Madaouéla, the N70°- N80° Tin Adrar cluster and the N130° N140° faults ([13], [14]). The litho-stratigraphic column of the Tim Mersoi Basin (Fig.3) comprises two sequences: (i) a lower sequence represented by the Carboniferous grey formations (Farazekat, Talak, Guézouman, Tchinézogue, Tarat, Madaouéla and Arlit) and (ii) a summit sequence corresponding to red formations of Permian (Izégouande, Tejia Tamamaït, Moradi) to Jurassic (Téloua) age ([12], [15], [16], [9]).

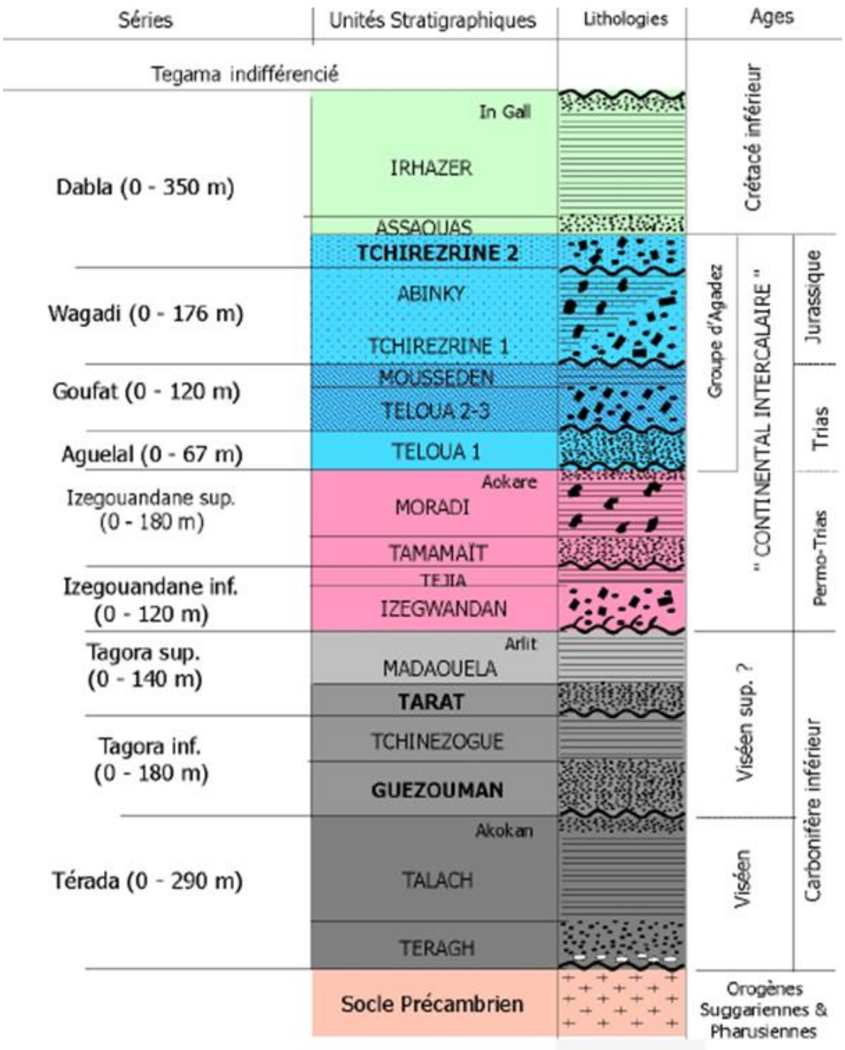

Fig. 3. Simplified lithostratigraphic column of the geological series of the Tim Mersoï basin on the western edge of the Aïr [15]

3.1 Hydrogeological Environment Of The Study Area

Hydrogeological studies conducted in the Arlit region have highlighted the presence of four permeable horizons constituting an aquifer system comprising from bottom to top the following aquifers: the Guezouman aquifer, the Tarat aquifer, the Izégouande aquifer and the Téloua aquifer ([17], [18], [19]).

Guezouman aquifer

Contained in the sandstone levels of the Guezouman, the host formation of the uranium deposits exploited by COMINAK [20], the Guezouman aquifer is characterized by significant lateral variations in thickness. The wall of the aquifer is represented by the Talak mudstone, while its roof corresponds to the Tchinezogue formation (very fine sandstone) [12], [8]. The Guézouman has a thickness varying from 30 to 70 meters for an average value of 40 meters. [21]. Transmissivities are also low, ranging from $1.5.10^{-6}$ to $1.8.10^{-4}$ m2/s. Storage coefficients are homogeneous values around $4.5.10^{-5}$ [22].

Tarat aquifer

The Tarat aquifer is contained in coarse to medium sandstones of the Tarat Formation ([18], [23], [24]), the host deposit of uranium mineralization mined by SOMAÏR. The wall of the aquifer corresponds to the Tchinezogue formation, (very fine sandstone) while its roof is represented by the arkosic sandstones of the Izegouande. The thickness of the aquifer is subject to very large variations due to both tectonic structures and the mode of sedimentation related to the energy of the depositional environment ([5], [24], [19]). Transmissives range from $7.4.10^{-5}$ to $1.1.10^{-3}$ m2/s, and storage coefficients are on the order of 10^{-5} [22].

Izegouande aquifer

The reservoir consists of arkosic, coarse-grained sandstones with micro conglomeratic levels and pasts ([5], [16], [8]). The wall of the aquifer is constituted by the Arlit unit. The Izegouande is unconfined east of the Arlit fault, while west of the fault it is captive and overlain by the Moradi, Tamamaïte and Téjia formations. The transmissivities are also low and range between 1.10^{-4} and 7.810^{-5} m²/s ([23], [24]).

Teloua aquifer

The Teloua aquifer is made up of coarse to micro conglomerate sandstones is unconfined and outcrops only west of the Arlit fault line ([8], [24]). The aquifer wall is by the arkosic red sandstone of the Izegouande.

4 MATERIAL AND METHODS

The methodological approach is based on the determination of the roof and wall elevations of the Tarat aquifer from the data obtained from the development boreholes (elevation and wall elevations of the Tarat). In addition, piezometric level measurements are taken in each borehole to locate the piezometric levels.

Logging data (log resistivity, log gamma ray) from all the drill holes was used to accurately determine the depth of the mineralized envelopes. Data processing was done using the SERMINE software.

The flow chart in Figure 4 summarizes the different operations carried out.

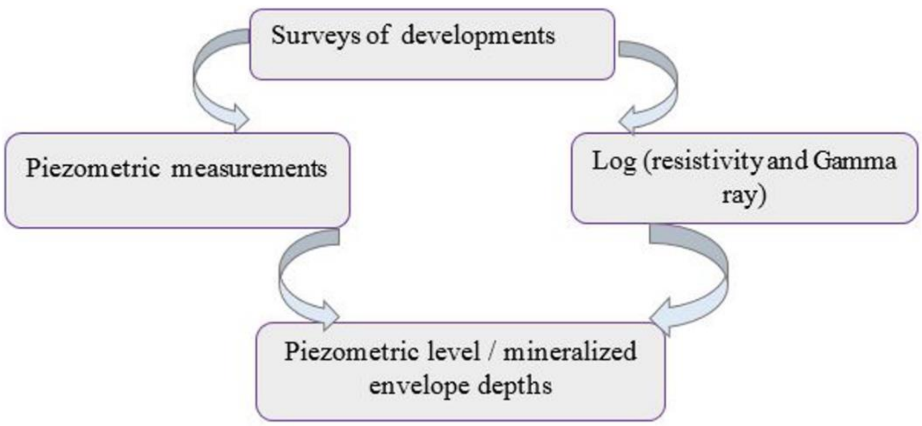

Fig. 4. Flow chart of the methodological approach implemented

5 Results And Discussion

5.1 Piezometry Of The Ariège Apophyse Sector

In the Ariège apophyse sector, the piezometric level varies from 350 to 360 m. The analysis of the isopiezes curves (Fig.5) shows several directions on which the flow takes place. The flow is generally from N-W to S-E. At the extreme N-W, (AI_2823 and AI_2824), the constant spacing of the isopies indicates a uniform flow. In addition, the flow axes are divergent and reflect recharge from the Tarat nappe ([25], [26]). In the southwest, (piezometer AI _2794), the flow axes diverge towards the north and northeast directions while in the southeast the isopiezes curves tighten indicating an increasing slope of the piezometric surface towards piezometer AI_2740 where the isopiezes become disturbed.

The isopiezes are tight in the South-East and the flow axes are globally East, directed towards the piezometer AI_2793 indicating an increasing slope of the piezometric surface and a relatively strong hydraulic gradient towards the piezometer AI_2740.

In the center (AI_2817), the isopiezes curves become deformed and progressively narrower towards piezometer AI_2773. To the east, the flow axes converge towards the piezometers AI_2793, AI_2773.). This convergence towards the east indicates a discharge of the Tarat water table towards the Ariège pit where the water is pumped for industrial need [19].

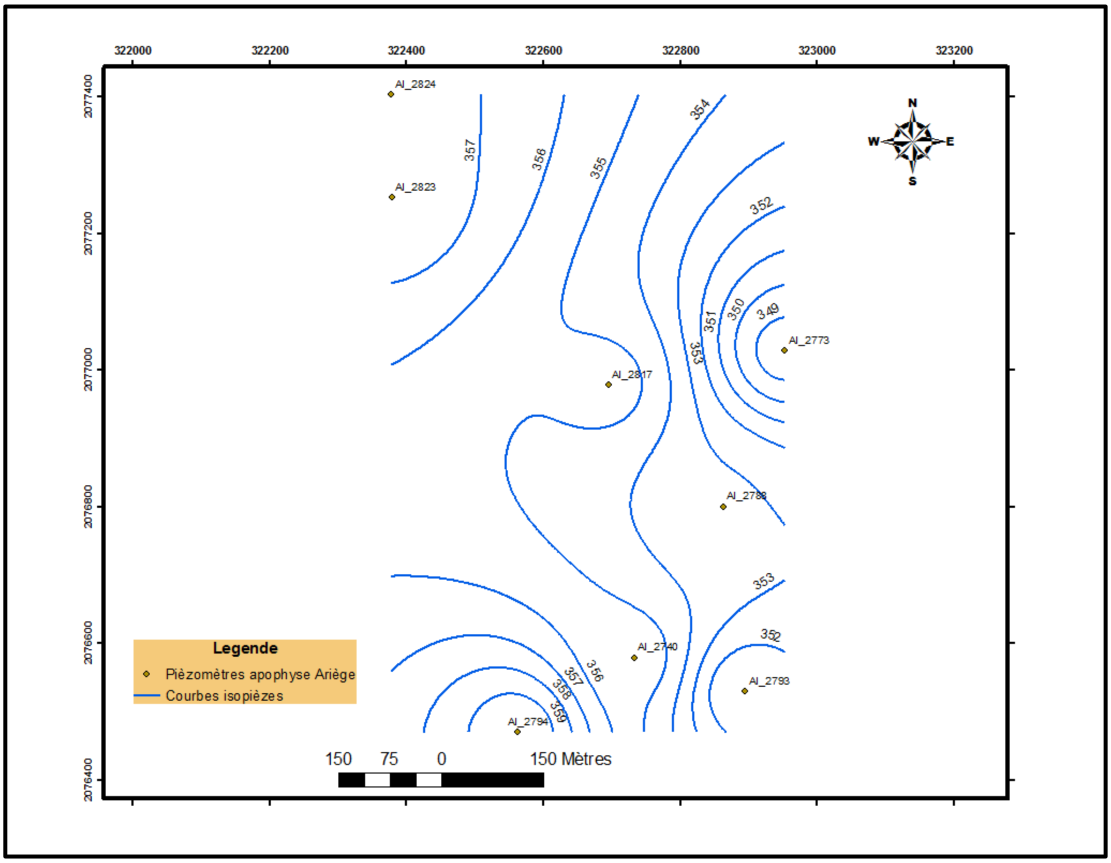

Fig. 5. Piezometric map of the Ariège apophyse sector

5.2 Location Of The Zones To Be Delineated

The North-South section (Fig. 6) gives the geometry of the mineralized envelopes as well as their dimensions in the Ariège apophyse prospect. By interpolation with the piezometric level (Fig.6), it appears that:

In the South, the wall of the mineralization is located at about 355 m while the static level of the water table is at 360 m. A part of the mineralized zones is above the static level of the water table, while another part is dipped under a water level of about 5m. This requires dewatering in this part.

In the center, the base of the mineralization is located at about 340 m, while the piezometric level is at 358 m, i.e. a water depth of about 18 m above the mineralized level.

To the north, most of the mineralization is above the water table. However, a small part of the mineralization is located under a water depth of about 3m.

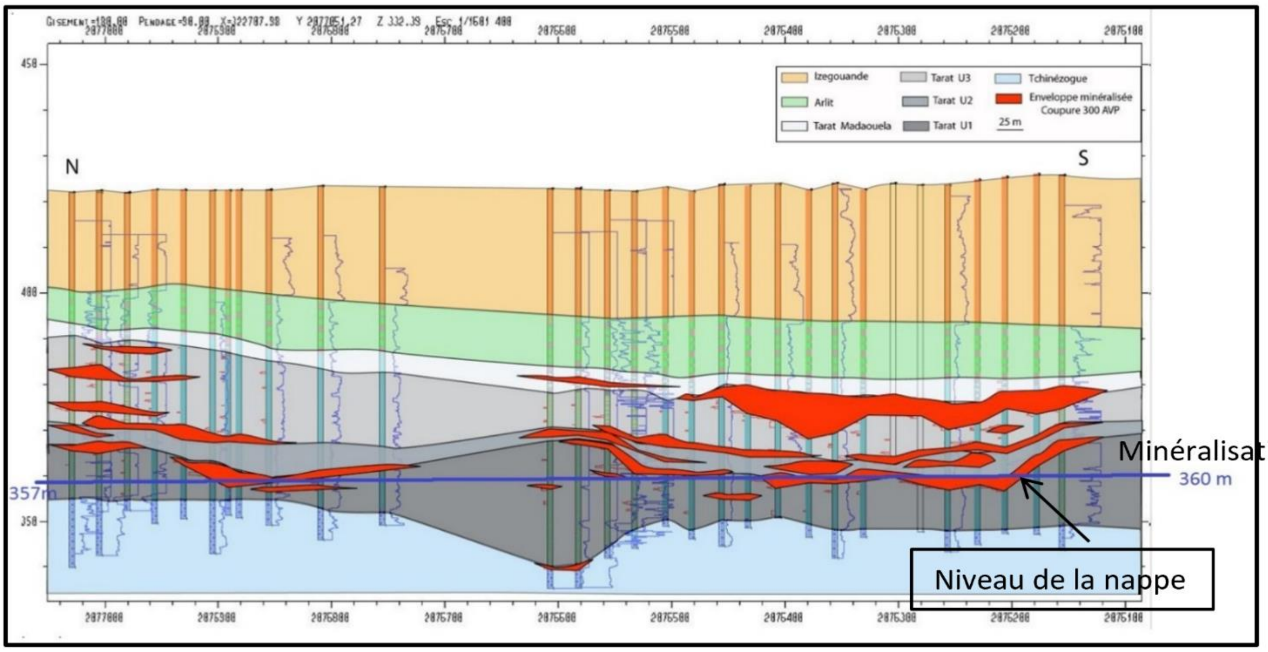

Fig. 6. North-South section and the level of the water table in relation to mineralization [19]

The East-West section (Fig. 7) shows that in the East, the mineralization is completely above the piezometric level. This indicates that mining can be carried out normally.

On the other hand, to the west, the wall of the mineralization is at elevation 353 m while the piezometric level is at 360 m. This shows that the mineralization is under a 7m water table.

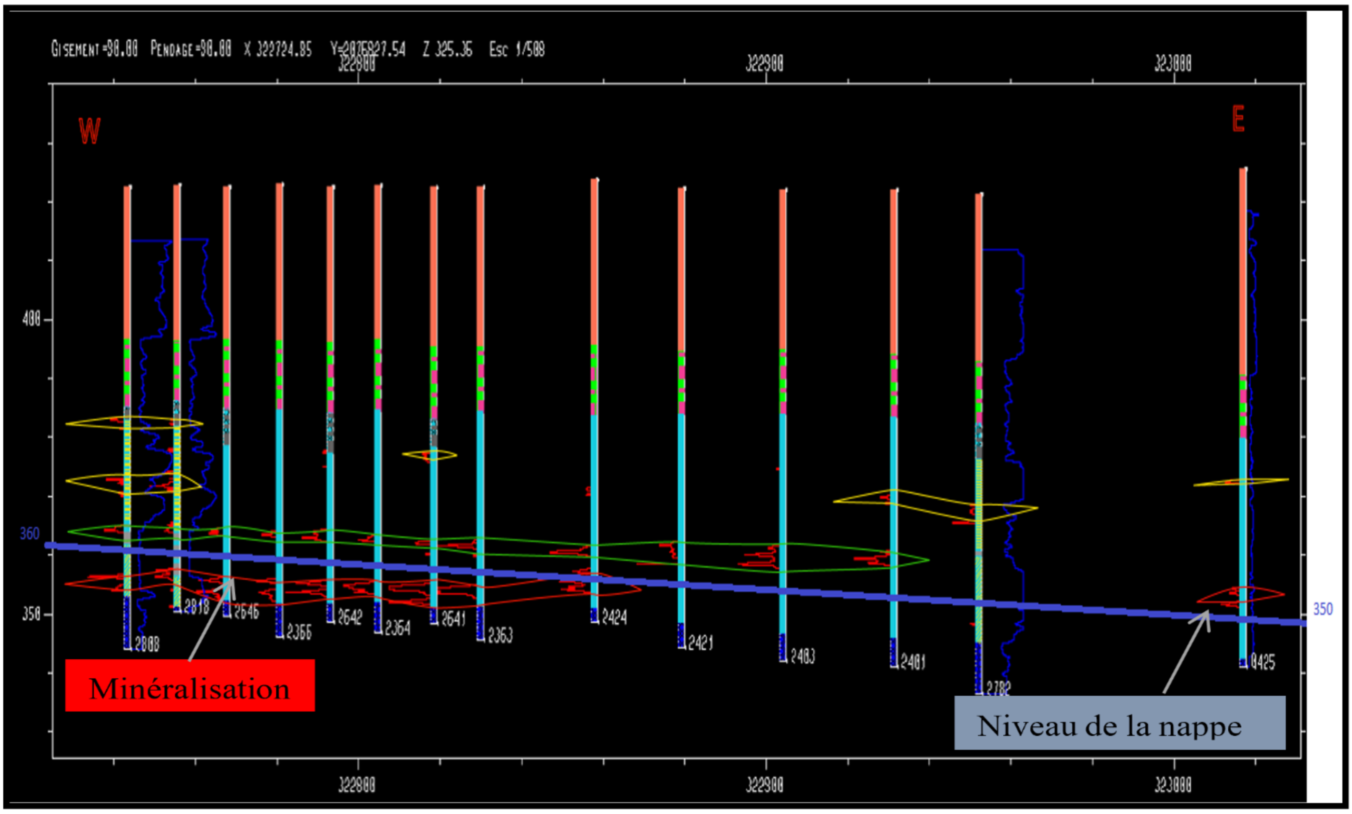

Fig. 7. East-West section mineralized level compared to the static level [19]

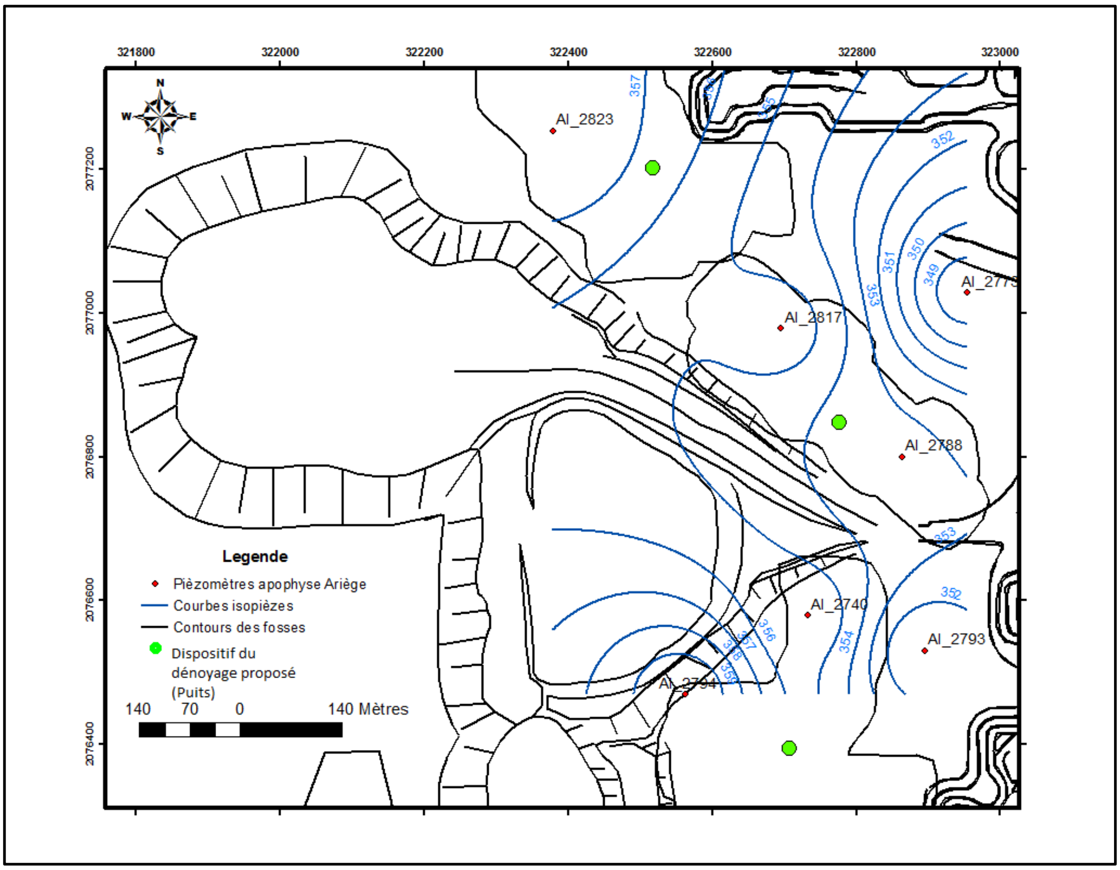

Fig. 8. Location of structures in relation to pits

Table 1. Location of structure

Borholes	WGS-84 X	WGS-84 Y	WGS-84 Z	Diameters
Well1	322957.8	2076791	355.4642	12"1/2
Well 2	322657	2077564	357.386	12"1/2
Well 3	322610.1	2077336	356.78	12"1/2

6 CONCLUSION

At the end of this study, it appears that most of the mineralization is above the water table. However, only a small part is drowned. These are the northern, western and central parts that require dewatering. Thus, it will be judicious to start mining the deposit in its eastern part.

At the level of the pits planned on the Ariège apophyse sector, only the central, North and West parts of the deposit require dewatering. This device includes three (3) pits inside the pits. In the eastern part, the piezometric level is towards the base of the mineralization, which allows for easy overburden removal.

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