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CONTRIBUTION OF REMOTE SENSING AND GEOPHYSICS TO HYDROGEOLOGICAL RECONNAISSANCE IN THE BASEMENT AREAS OF THE GUERA REGION: CASE OF THE CITY OF MONGO (CHAD)

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ABSTRACT

The aquifers of the base cracked are excellent reservoirs of water in the Guera region in general and in Mongo town in particular. In fact, the basement fractures and fissures of the base are the areas of preferential flow to groundwater reserves in this area. The study of lineaments has been conducted using Landsat 8 images to highlight these fractures. All the techniques used in remote sensing resulted in the enhancement of the structural and linear elements contained in the raw images, thus allowing a better cartography of the geological accidents. The map obtained after the treatments shows a high density of lineaments of very variable sizes. This map can be used as a basic document for the implantation of boreholes in this basement area. The map of the lineaments obtained has been validated by electrical surveys allowing some of these lineaments to be intersected in order to determine those which generate good flows or those which reflect the influence of mega fractures. A statistical analysis of the parameters that can influence the productivity of the boreholes (total depth, alteration thickness, specific flow) was performed. This analysis reveals that total depth has no effect on drilling productivity. A large thickness of alteration increases the chances of having a significant flow. And beyond 60 meters deep in the cracked rock, the chances of getting a consistent flow decrease. This work has improved knowledge of the fractured aquifer in the study area. They will guide future hydraulic campaigns for the identification of potential sites for the implementation of structures in the basement area.

Keywords: remote Sensing, geophysics, Basement fracture, lineament, productivity, Mongo.

I. INTRODUCTION

The Guera region located in the central Chad, at the extreme east of the Chad basin, is composed of the crystallophyllian basement of Precambrian age. This crystalline basement is either flush or underlying at shallow depth, does not contain any water reserve for the healthy state, however, it is often interspersed with fractures, cracks, faults and dikes ground.

These fracture networks, fundamental in groundwater research, thus constitute the main underground flow axes (Lasm, 2000, Youan et *al.*, 2008, Ngo et *al.*, 2010, Yao et *al.*, 2012).

Thus, given the geological complexity, aggravated by climate change, the region of Guera, like that of other regions of Chad, is experiencing difficulties in access to groundwater resources. In order to overcome this lack of access to water of quality and quantity, the search for new potential sites for the construction of hydraulic structures seems essential. Thus, remote sensing coupled to the geophysical method for the identification of potential areas for borehole implantation was used. Indeed, the combination of these two methods will detect the different geological structures through the extraction of lineaments followed by geophysical prospecting to identify the best places likely to give a good flow rate for the supply of the city of Mongo.

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Geographical and Geological Context

The Guera region is located in the center of the country between the 10th and 14th degrees of North latitude and the 18th and 20th degree of East longitude with an area of 23,262 Km^2. The town of Mongo, our study area is between 12 ° 06 and 12 ° 18 North latitude and 18 ° 30, 18 ° 50 East longitude. The city of Mongo, with its spectacular massifs, marks a geographical transition between a North sahelian frankly pastoral and, the South sudanese, more largely agricultural.

Rainfall ranges between 300 and nearly 900 mm in the south, with certainly orographic effects (Bertrand & Lagnaba, 2011). The relief therefore shows many inselberg ranges opening onto three large watersheds, including the Batha Fitri, the Aouk Salamat and the Batha de Lairi Basin. The vegetation undergoes the rainfall gradient and is in the form of a shrub savannah to clear according to the latitude and the relief. It is dominated much more by acacias (*Senegal, Seyal, Nilotica, Radiana*) but also *Zizyphus, Ficus*.

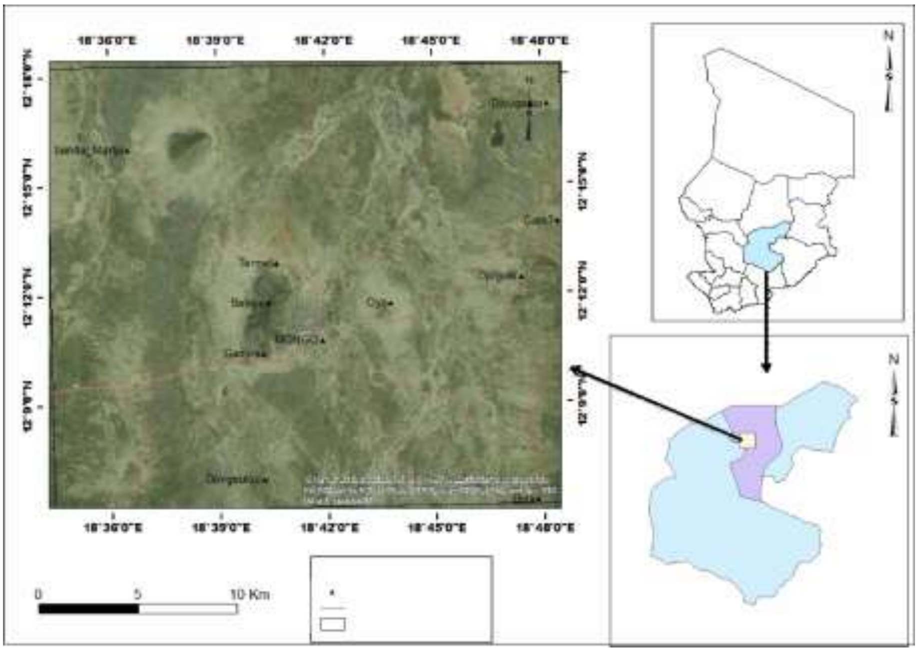

Figure 1: Location of the study area

Located in the heart of the Chadian basin, the Massif Central is an orographic unit grouping three (3) main massifs-those of Abu Telfan, Kengas and Melfi, as well as many small secondary and inselberg massifs separated by by areas of arenas, sandy(Schneider, 2001).

Among the formations that represent the continuation of those of Ouaddai, we can distinguish: (i) metamorphic rocks often enclave and meta-volcano-sedimentary series which is composed of conglomerate, shale, graphitic and marbles. The lands consist of laterite, desiccation clay or sand, or a mixture of the three in varying proportions (Kusnir, 1995); (ii) intrusive rocks that represent almost all of the outcrops of the Precambrian basement, mainly in the form of granitic and malgachitic-facies rocks (Kusnir, 1995).

In addition to the metamorphic and intrusive rocks mentioned above, meets loose formations due to alteration. They recover or develop at the expense of the crystalline basement (alluviums, colluviums, laterites, clay-sandy arena and grainy arena) by the effect of alteration. Their thickness varies according to the regions and the climatic zones but they reach on average 10 to 20m in granite gneissic zone and 15 to 40 m in schisteux zone.
In terms of hydrogeology, groundwater in the city of Mongo is linked to alluvial formations in the plains and valleys and to altered or fissured basement zones (Engalenc, 1990).

Therefore, the aquifer is discontinuous and groundwater circulates only through fracture networks. The study area is covered by a base of granite mountain with overlays of alterites and recent sedimentary deposits more or less variable, where there is no generalized groundwater (Kusnir, 1995).Likely to provide water of high potential have various geological natures, which can be demonstrated the existence of two types of water table:

(i) basement plies encountered on the edge of the crystalline mass enclosing arenas and pediments that s accumulate at the foot of the massifs, as well as those which are in the alterites; (ii) alluvial aquifers characterized by sub-fluvial aquifers which occupy the alluvial deposits of the main valleys of the big wadis; plains of flooded depressions or ponds, which are related to the presence of predominantly sandy beds beneath the argillaceous basins of ponds or flooded areas. On the hydrographic, the study area is divided into three parts, including the Batha-Fitri Basin, the Salamat Basin and the Batha Basin. The main rivers are those of Bang-bang and Faraleh which flow from north to south with temporary flow.

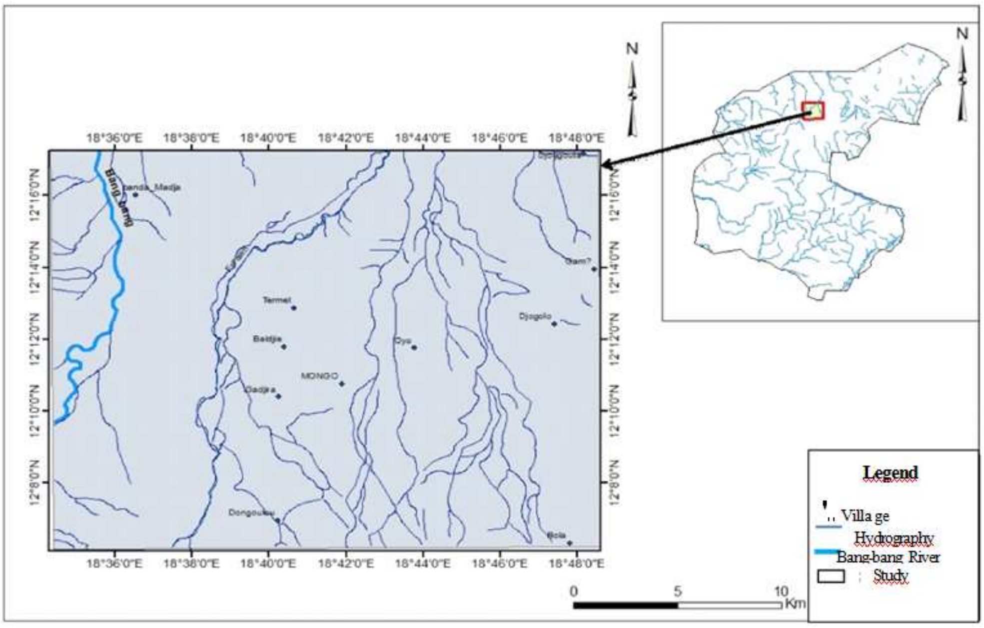

Figure 2: Hydrographic Networks

II. MATERIALS AND METHODS

Materials

In the context of this study, three forms of data were used. These are: (i) hydrogeological data through the database of the Ministry of Water and Sanitation; (ii) remote sensing data through the analysis and interpretation of satellite images; (iii) geophysical data through field prospecting. The satellite image used in this study is that of Landsat 8, scene 182 - 051 in the projection system: EPS G 43263_WGS 84 / UTM Zone 34N. The scene is acquired on February 27, 2016, when the sky is clear allowing a good shot. The hydrogeological data are those of the drilling characteristics (static level, flow rate, thickness of altérites and depth) to make a comparative study between the parameters of productivity. These data were obtained from the database of the Ministry of Water and Sanitation.

The geophysical data acquisition equipment used in this study consists of an ABEM type resistivity meter with its accessories (AB current injection coil, NM potential difference measuring coil, electrodes, double decameter, masses, compass, GPS, etc.). The data processing equipment consists of software like: Envi 5.1 for the processing of satellite images, Surfer.11 for the realization of piezometric maps, PCI Geomatica 9.1 for the automatic extraction of lineaments, WinSev6 for the realization of the curves of vertical electric sounding.

Methodology

Hydrogeological recognition of an aquifer in a basement area requires the use of structural maps of great precision. Indeed, the study of lineaments or geological structures makes it possible to meet two objectives: (i) the orientation of reconnaissance campaigns by defining potentially favorable zones; (ii) the selection of punctual sites for the implantation of boreholes (Chapellier, 2000). The families of discontinuities are defined by their orientation, their opening, their persistence, their density as well as their geological origin (Rey, 2007). Thus, in the framework of this study, remote sensing and geophysics were used as hydrogeological recognition tools for basement areas.

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In addition to remote sensing and geophysical prospecting, a statistical analysis was conducted using data from 63 existing drill holes in the Mongo sub-prefecture. These data were acquired in the database of the Ministry of Water and Sanitation. 2.2.1. Exploitation of remote sensing images The lineaments represent linear geological objects or alignments of geological objects sufficiently close together, topographic discontinuities or geomorphological structures inherited from ancient topographies (Theodore et *al.,* 2012). The methodology of the treatment of optical satellite images and the extraction of lineaments is a synthesis of the work of Kouamé et *al.,* 1999; Jourda et *al.,* 2006; Youan et *al.,* 2008. Image processing consisted of contrast enhancement, Principal Component Analysis (PCA) and band combination and directional filtering to help identify lineaments. Principal Component Analysis (PCA) is a mathematical transformation that consists in calculating the eigen values and eigenvectors of the variance-covariance matrix computed from a series of images, then the main components of the multiband digital count. -spectral (Bonn and Rochon, 1992). It was performed on the seven Landsat-8 ETM + soundtracks, thus generating neo-channels. The PCA has brought out the information contained in these multi-spectral images by eliminating data redundancy. Indeed, the linear geo-structures are better visible on the first principal component (main component 1 or PC1) than on the multi-spectral image. The application of the high pass filter (modified Laplacian), directional filters 7x7 Sobel type has enhanced even better discontinuities images corresponding to structural lineaments. They accentuate the lithological and structural discontinuities in the four directions N-S, NE-SO, NO-SE, E-O (Issiaka et *al.,* 2012). Table 1 presents the different filters used during this
study.

Table 1: Directional filter of sobel 7 x7

N-S								E-O						
1	1	1	2	1	1	1		-1	-1	-1	0	1	1	1
1	1	2	3	2	1	1		-1	-1	-2	0	2	1	1
1	2	3	4	3	2	1		-1	-2	-3	0	3	2	1
0	0	0	0	0	0	0		-2	-3	-4	0	4	3	2
-1	-2	-3	-4	-3	-2	-1		-1	-2	-3	0	3	2	1
-1	-1	-2	-3	-2	-1	-1		-1	-1	-2	0	2	1	1
-1	-1	-1	-2	-1	-1	-1		-1	-1	-1	0	1	1	1
NE-SO								**NO-SE**						
0	1	1	1	1	1	2		2	1	1	1	1	1	0
-1	0	2	2	2	3	1		1	3	2	2	2	0	-1
-1	-2	0	3	4	2	1		1	2	4	3	0	-2	-1
-1	-2	-3	0	3	2	1		1	2	3	0	-3	-2	-1
-1	-2	-4	-3	0	2	1		1	2	0	-3	-4	-2	-1
-1	-3	-2	-2	-2	0	1		1	0	-2	-2	-2	-3	-1
-2	-1	-1	-1	-1	-1	0		0	-1	-1	-1	-1	-1	-2

Extraction of the lineaments was carried out on the filtered or PCA-derived bands (initial and transformed bands). The treatments and filterings made it possible to accentuate and facilitate the detection of discontinuities-images, in order to ensure their survey by simple visual observation. Thus, only lineaments of structural origin were mapped in this study. The validation of these lineaments allowed us then, by extrapolation, to give a structural value to all of our lineaments and to go from the use of the term of lineament to that of fracture

Electrical surveys

Electrical methods represent all the methods based on the study of the electrical properties of geological formations. These properties are essentially the electrical resistivity and its inverse conductivity. For Lachassagne et *al.,* 2005, electrical methods seem the most appropriate, because of their lightness, their relatively low cost, their ease of implementation and especially their high reliability. As part of this study, the geophysical methods applied are electric dragging and electric sounding according to the Schlumberger approach. The principle of the electrical method is to inject a DC current into the ground using two electrodes A and B and to measure the potential difference between two other electrodes M and N between A and B. The electrical profile is the preliminary method to any geo-electrical study and serves as a basis for the implementation of electrical soundings (Kouassi et *al.,* 2014). Thus, the electrical profiles were used to follow the lateral continuity of the layers in a given position, and to confirm the presence or absence of anomalies (Bakkali and Bouyalaoui, 2004). The Schlumberger device was used with characteristics geometric AB = 300m, MN = 20m with a measuring pitch of 10m. The electrical sounding method was also carried out according to the Schlumberger device, to the right of apparent resistivity anomalies. They make it possible to determine the

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thicknesses, the nature of the vertical structures and the depth of the anomaly under the measuring station. The principle is to use four electrodes that are regularly spaced from the center of the survey to take into account more and more land. For this study, the Schlumberger device was used with an AB geometry ranging from 1 to 300m and MN / 2 from 0.5 to 10m. The modeling of the survey data was carried out using the GEOSOFT WinSev 6.3 software. This is an iterative interpretation using a 1D geo-electric model (horizontally stratified medium) and leading to the establishment of models giving the characteristics of the terrain traversed, ie to estimate the depth at which is the resistant formation and the depth of its substratum vertically to the SEV. Thus, soundings that give interesting investigation depths have been selected for drilling.

III. RESULTS

Contribution of remote sensing

This section is reserved exclusively for presenting results from the Landsat image processing process to extract geological information. At first, the preprocessing (radiometric and geometric) allowed us to identify the noises contained in the raw image during its acquisition. By applying the radiometric calibration to the Landsat raw image, we obtained a radiance image (fig.3). A contrast enhancement by the linear spreading technique has been applied to the radiance image to better perceive the information contained in these bands. An atmospheric correction was applied to the radiance image to obtain a much more perceptible derived image called reflectance (Figure 4).

Figure 3: Image initiale

Figure 4: Image réflectance

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The colored composition has highlighted the contrast of the image by showing the color of the bare soil, vegetation and streams. As for the arrangement of the colors, it goes from one person to another and all depends on how one and the other perceive the image. We composed the three bands by giving the red band 5, green band 4 and blue band 3 (Figs 5 and 6).

Figure 5: Vraie couleur (RVB : 432)

Figure 6: Fausse couleur (RVB : 543)

Principal component analysis uncorrelated tapes and collected information on the first band (ACP1), which alone accounts for 99% of the information. The composition of bands 6 (SWIR 2) for rocks, 4 (Near infrared) for vegetation and 2 for water gave us the following picture (Fig.7 and Fig.8).

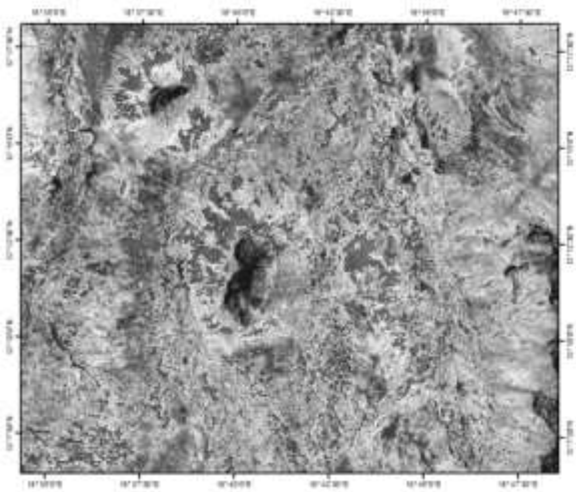

Figure 7: ACP

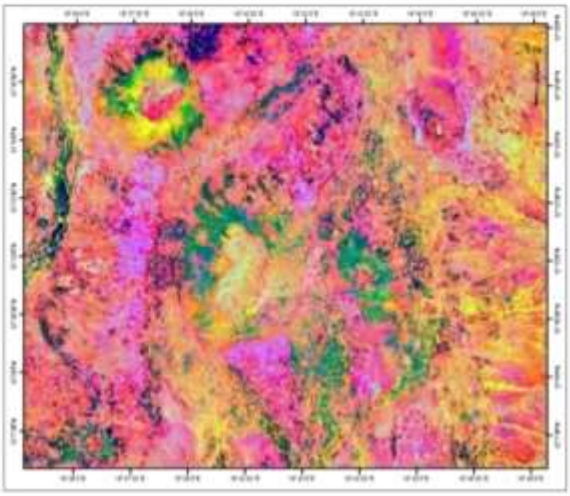

Figure 8: ACP selective

As part of this study, directional Sobel directional filters NS, NO, EO, NE all, size 7 x 7 were applied to the CP2 image to make certain discontinuities more perceptible. This filter is a more selective variety of directional filters where the values of the convolution matrix are determined according to the distance from the central pixel (Fig.9 and Fig.10).

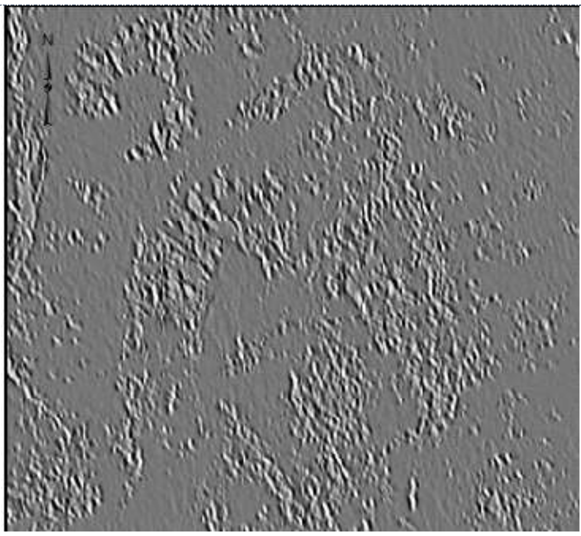

Figure 9: A-NW

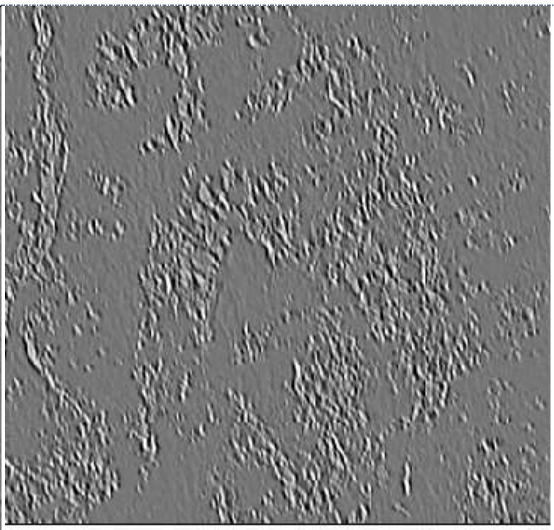

Figure 1: C – NE

The lineaments were extracted automatically on the transformed strips, coming from the ACP1 through the "line extraction" module of the PCI Geomatica software. Only linear structures of structural origin have an interest in this study. Indeed, any element that does not correspond to the lineament has been eliminated. At the end of this process, the lineament maps were made (Fig. 11, Fig. 12, Fig. 13, Fig. 14).

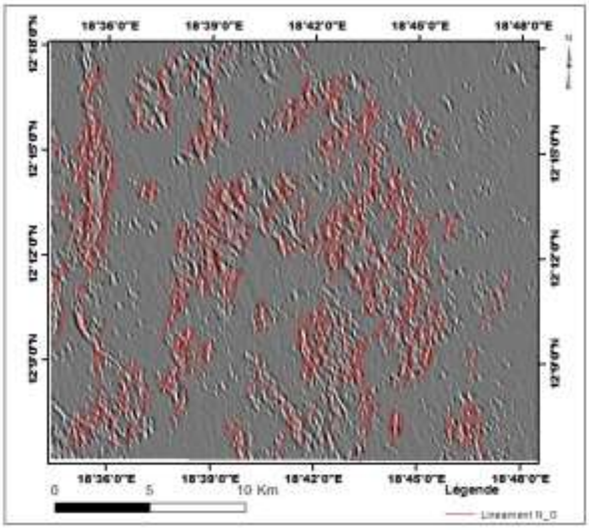

Figure 11: Lineament Overlay NO to NO direction filter

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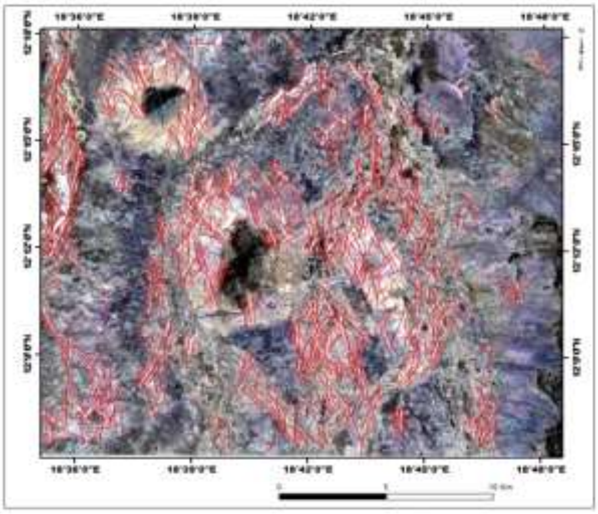

Figure 12: Lineament Overlay NO has the image reflectance

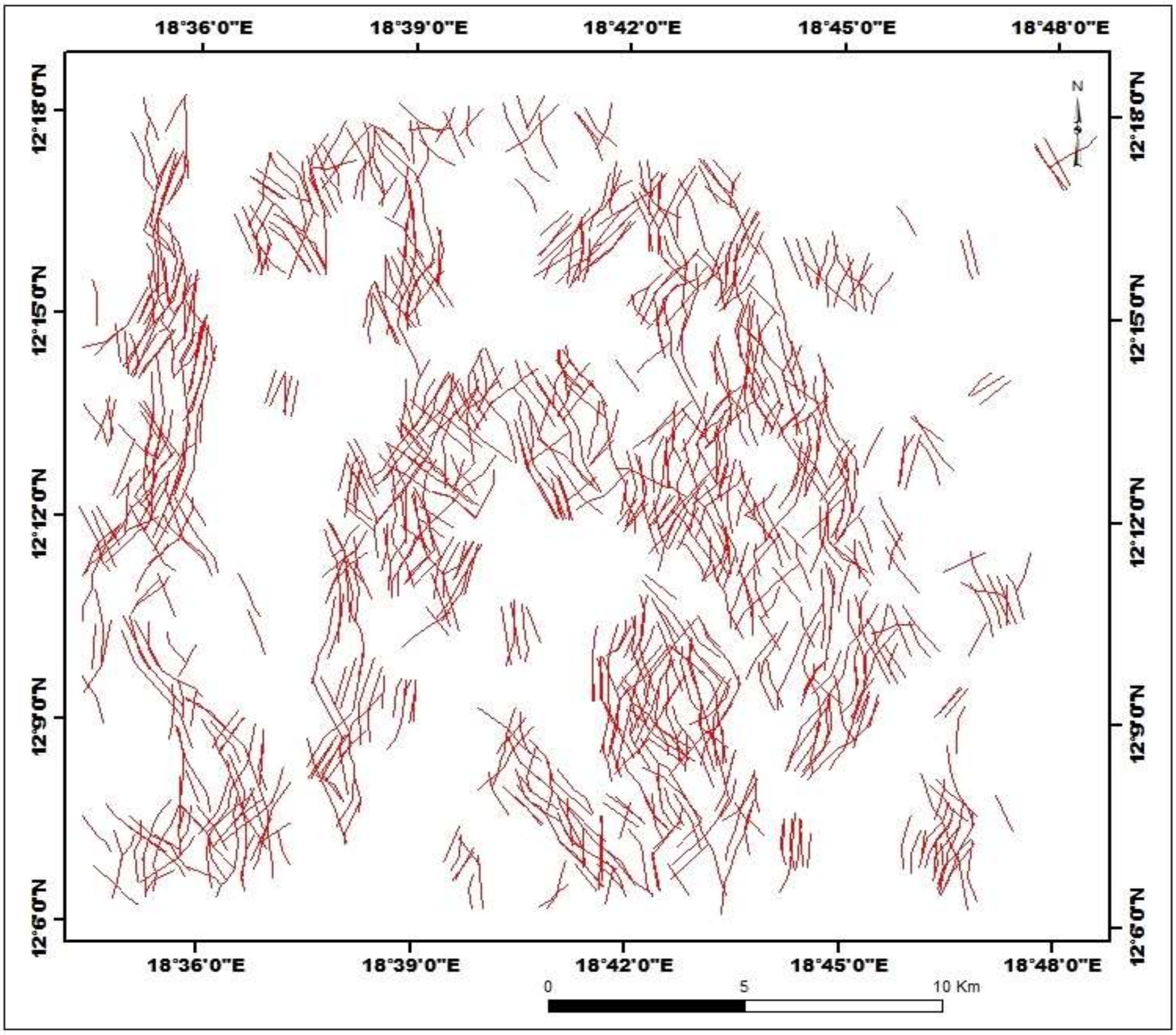

Figure 13: Linear map of the study area

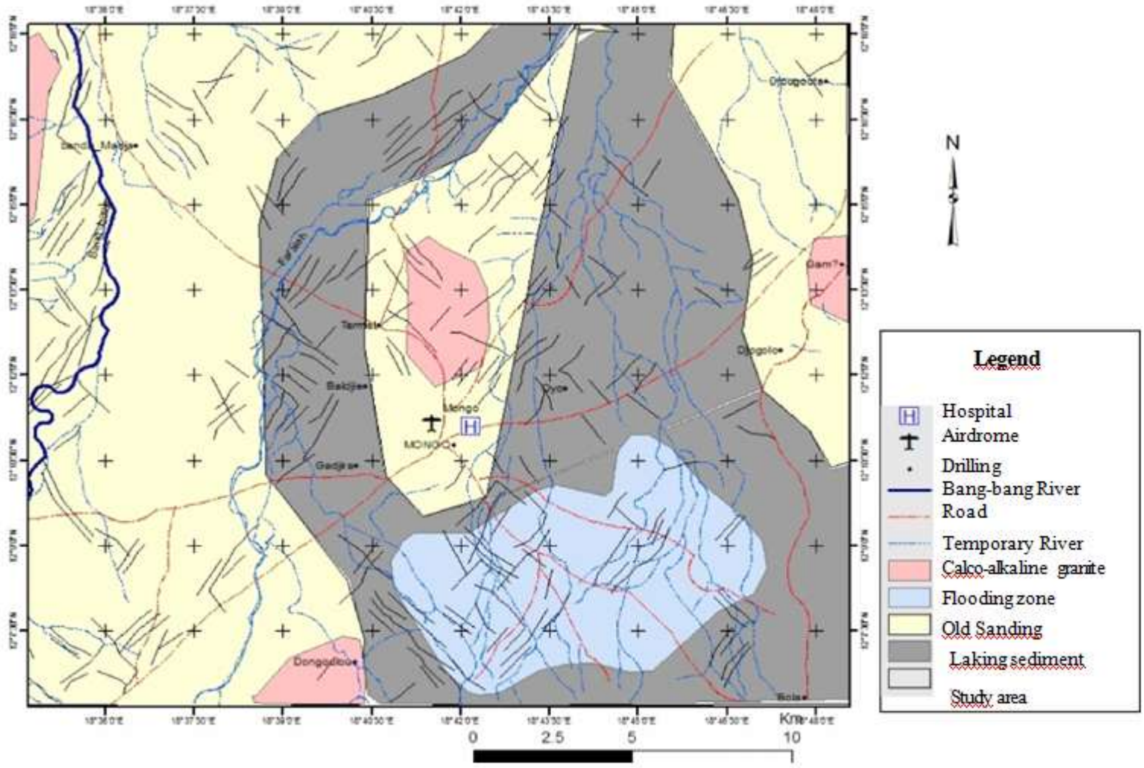

Figure 14: Hydrogeological map of the area

Contribution of geophysics

The electrical profiles were made perpendicular to the lineaments highlighted by the processing of satellite images. In the field, the resistivity values measured through the electrical profiles for each point are plotted on a semi logarithmic paper where the position of the points is plotted on the abscissa (normal scale) and the resistivities on the ordinate (log scale). Thus, on the graph, the minima are considered conductive anomalies and the maximums as resistant zones. According to their preponderance, the anomalies (minimums) are marked for, to be the object of the electrical soundings (SEV). Tables 2 and 3 give two examples of the data acquired during the electrical profile, whereas Figures 15 and 16 give the presentations of the profiles 1 and 2.

Table 2: Example 1 of the electrical profile

D(m)	ρa	D(m)	ρa
0	162	70	97
10	139	80	87
20	66	90	116
30	79	100	128
40	81	110	113
50	80	120	121
60	53		

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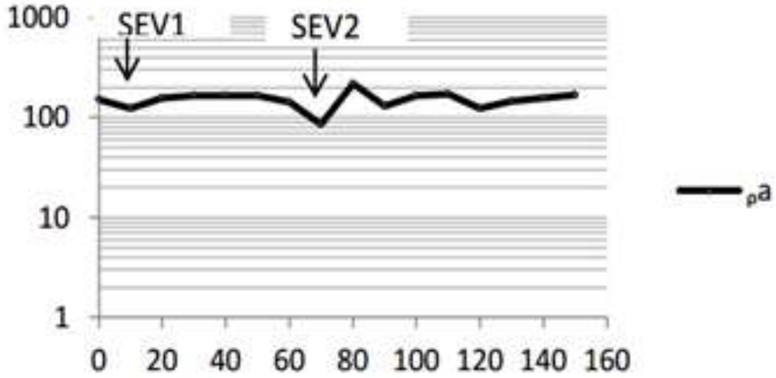

Figure 15: Curve of the electrical profile 1

Table 2: Example 2 of the electrical profile

D(m)	ρa	D(m)	ρa
0	151	80	217
10	122	90	131
20	157	100	164
30	164	110	170
40	166	120	124
50	165	130	146
60	142	140	156
70	85	150	169

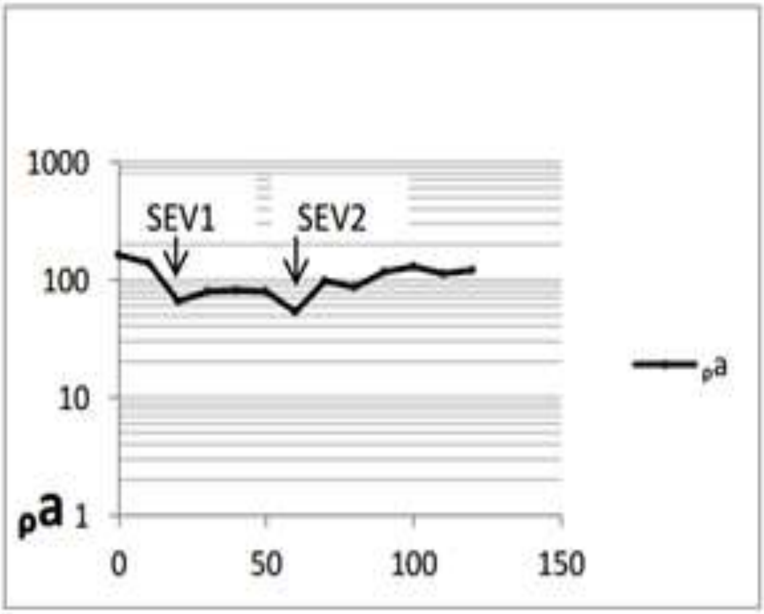

Figure 16: Curve of the electrical profile 2

The curve of the electrical probing plotted in bi-logarithmic coordinates represents the evolution of the apparent resistivity (a) as a function of AB / 2. Its interpretation using Winsev and IX1D software, allows to calculate the geo-electrical characteristics (thicknesses and resistivities) of the different layers traversed by the current. Table 4 shows an example of the vertical electrical drill data and Figures 17 and 18 show the survey curves obtained after the interpretation of the data by the Winsev software, whereas Tables 5 and 6 specify the characteristics of the prospected lands. . Table 7 summarizes the geophysical data acquired during this study.

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Table 4: Vertical Electrical Survey Data 1

AB/2	MN/2		Rho	Rho
1	0.5		57.367	
1.5	0.5		66.0028	
2	0.5		85.3687	
3	0.5		122.81325	
4	0.5		155.7832	
5	0.5		177.1902	
7	0.5		168.3825	
10	0.5		74.85838	
15	0.5	5	31.54546	24.7915
20	0.5	5	14.748776	19.32395
30		5		20.809565
40		5		4.9108815
50		5		39.876037
70		5		52.24426
100	10	5	66.02666	51.45675
120	10		69.867512	
150	10		128.503872	
200	10		212.485056	
250	10			
300	10		185.17961	

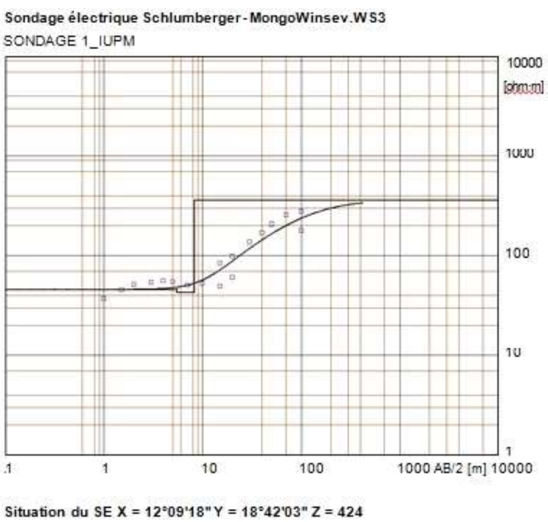

Figure 17: SEV Interpretation Curve 1

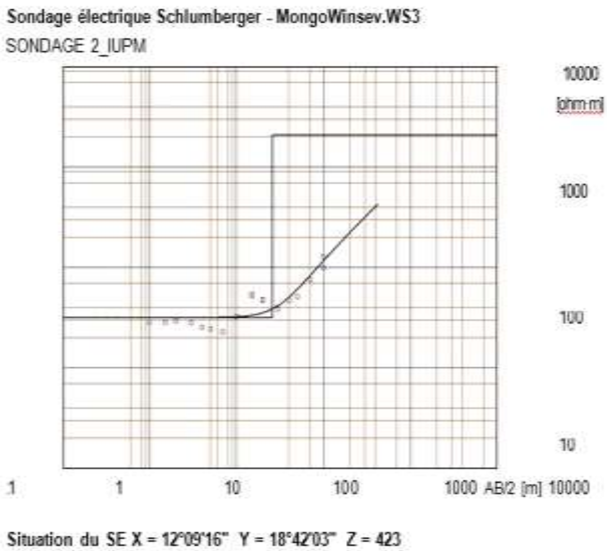

Figure 18: SEV Interpretation Curve 2

Table 5: Field characteristics of the SEV 1

N°	Resistivity (Ωm)	Thickness (m)	Depth (m)	Altitude (m)
01	46	5.5.	0	424
02	43	2.8	5.5	418.5
03	360		8.3	415.7

Table 6: Field characteristics of the SEV 2

N°	Resistivity (Ωm)	Thickness (m)	Depth (m)	Altitude (m)
01	32	26	0	423
02	2087	-	26	397

Table 7: Summary of Geophysical Data

Site	GPS coordinates of the points	Shape of curves Profile	Shape of SEV curves	Estimated depth	Priority
IUPM	E : 18°42'03" N : 12°09'18" E : 18°42'03.9" N : 12°09'16.1"	U V	SL	60m 63 m	Ves 1 Ves 2
Face IUPM	E : 18°42'07.5" N : 12°09'23.8"	U	BB	68 m	Ves1
Pilot School	E : 18°41'22.1' N : 12°11'32.9'' E : 18 4121.4'' N : 12°11'34.0'' E : 1841'22.2'' N : 12°11'35.2''	U V M	B&BB	100 m 75 m 80 m	Ves1 Ves2 Ves3
Cmle School	E : 18°41'29.0'' N : 12°11'16.5'' E : 18°41'29.0'' N : 12°11'16.5''	V V	B&BB EBD	75 m 50 m	Ves1 Ves2
Game School	E : 18°47'37.4'' N : 12°13'56.4'' E : 18°47'37.4'' N : 12°13'56.7'' E : 18°47'31.6'' N : 12°13'37.8''	U W W	B&BB	70 m 85 m 70 m	Ves1 Ves2 Ves3
Hospital	E : 18°41'01.4'' N : 12°10'40.8'' E : 18°40'56.5'' N : 12°10'40.1'' E : 18°41'54.2'' N : 12°10'39.9	V K U	SDB BBB	100 m 80 m 70 m	Ves1 Ves2 Ves3
Health center	E : 18°40'56.6'' N : 12°10'44.5'' E : 18°40'56.7'' N : 12°10'41.7'' E : 18°40'53.9'' N : 12°10'43.1'' E : 18°40'56.0'' N : 12°10'44.6''	V V V	B&BB BBB	100 m 90 m 70 m 60 m	Ves1 Ves2 Ves3 Ves4

SL: Slow Lift; BB:Boat Background; B&BB: Bell and Boat Background; BBB: Bell Boat Background; SDB: Staircase with Descending Branch

IV. DISCUSSION

Statistical analysis of productivity parameters

Access to groundwater is not fully controlled in the Guera region and more particularly in the sub-prefecture of Mongo, object of the study. To the great difficulty of determining the fractures often with an operating rate lower than 5m^3/h, is added the hydrogeological and hydrodynamic parameters which play on the productivity of the works. Thus, only two possibilities allow us to exploit the groundwater of the locality: (i) the first is the exploitation of the reservoirs of alterites; (ii) the second is the exploitation of fracture reservoirs. Beyond fractures, other parameters can influence the productivity of structures. These parameters include, among others, the thickness of alterites, the flow and depth of the boreholes as well as the petrographic nature of the formations. The statistical analysis of borehole data in the Mongo sub-prefecture has made it possible to gain a better understanding of the flow variation as a function of the productivity parameters of the structures in order to clarify the geophysical prospecting in the area.

The productivity of water boreholes in the area can be evaluated by the "maximum operating" flow, calculated on the basis of pump test results using the standardized method defined by the CIEH. The graph of Figure 19

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highlights the relationship between the static level and the flow. In this analysis, most of the boreholes with high flows of the order of 5m3 / h are found in alteration thicknesses between 5 and 25m. The flow tends to lower when the static level increases thus giving a large flow.

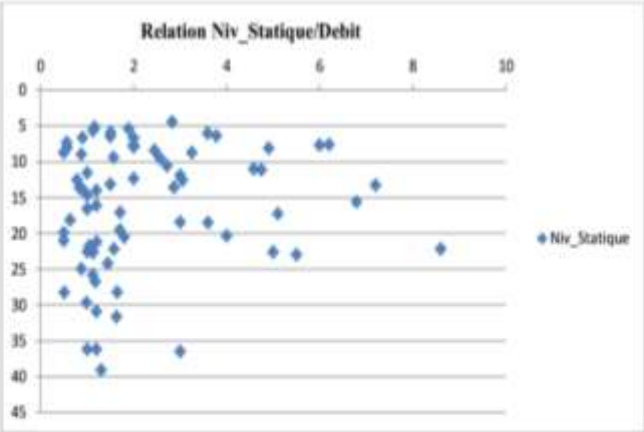

Figure 19: Relationship between the NS / debit

Statistical analysis has also shown that total depth is one of the parameters on which productivity depends. Because the highest flows were obtained in the granitic basement at relatively average depths between 30 to 60m (Fig.20). Then there is a sudden drop in flows between 60 to 80m deep, significantly lowering the productivity of the structures.

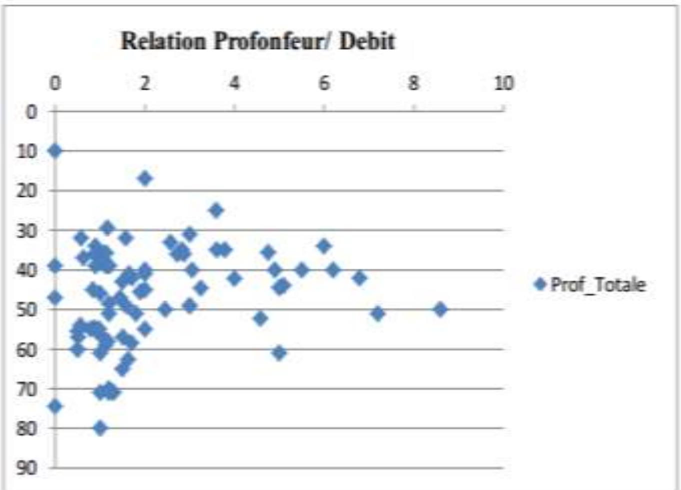

Figure 20: Relationship Between Depth / Flow

The analysis also allowed us to note that most of the drillings with flow rates greater than or equal to 3m^3/h are found in thicknesses of alterites between 2 and 15 m. Others (strong flows) are in thicknesses of alterites between 11 and 26m (Fig.21). This allows us to say that flows believe with the high thickness of alterites. In view of this, it can be concluded that there is a positive relationship between the flow rates and the thickness of alterites in the granitic bedrock. Thus, for the hydrogeologist it is important to look for zones with a large thickness of alteration in a granite domain.

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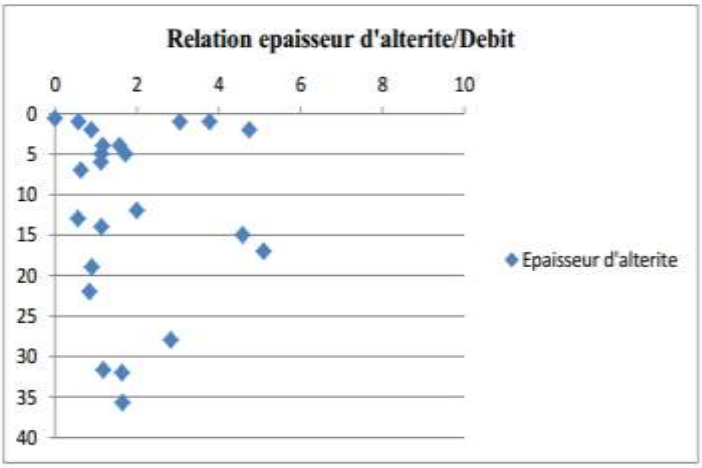

Figure 21: Relationship between alterite / flow thickness

Hydrogeological potential analysis

The application of pretreatment and processing techniques has resulted in the radiometric enhancement of images making them more expressive and finer for structural mapping. Thus, the detailed map of the lineaments (numerous accidents) was made thanks to an interpretation of the images derived from the different processing techniques (PCA, enhancement by the Sobel 7x7 filters) as well as the superposition of this one to the other maps existing, followed by the removal of anthropogenic elements (roads, tracks, etc.). Dark wells above the fractures thus mapped, or better still, where two or more fractures intersect, generally provide a large flow of groundwater (Lattman & Parizek, 1964, Parizek, 1976). In other words, the nodes formed by the intersections of the fractures would have significant water potentials. The verification of the treatment result led to a geophysical study in the study area. The choice of better implementations on a geophysical profile takes into account the form of the anomaly highlighted on the resistivity profile. It follows from this interpretation that anomalies in the form of U, H or V give a good flow. Indeed, by experience, the drilling done on this type of anomalies gave the best flow rates. Based on the principle of Dieng et *al.,* 2004, the morphology of the ground and the existing drillings, the profiles realized following the respect of the principle of electrical drag (perpendicularity) and those of the existing data showed us interesting anomalies which have more than 20 m long (point where the resistivity has dropped). At 10 and 70 m for the first profile and 85 and 122 m for the second. U-type and V-type anomalies are dominant.

The "down-mounted" or "boat" or "bell" sounding curve characteristic of three-layer sounding, illustrates the very thick layers of alterites that can probably make fractures unreadable. It should be noted that a conductive anomaly may produce a negative bore in that the fracture may contain sludge or in other cases, the water that has circulated in this fracture has migrated to another zone. We have seen in the statistical analysis of the productivity of the works that the layers of alterites receive water directly from precipitation and are able to accumulate huge amounts of infiltration. Indeed, flow rates greater than 5m^3 have been encountered in alteration thicknesses between 20 and 50m.

The survey curves obtained from the "lift up" type show the very interesting existence of hydrogeological fracture, namely the existence of the cracked base between the conductive horizon and the sound base. The greater the thickness of the cracked base, the more it is expressed on the curve by a marked upward drag. Indeed, when the thickness of the crushed area of the basement roof becomes large, the branch of the lift becomes hesitant or trailing. For Savane et *al.*, 1997 this type of sounding curve reflects the influence of mega fractures because they present disturbances in the rising branches.

On the other hand, the sounding curves of the "bottom of boat and bell" type characterize the lateritic cuirass zones. Generally this type of curve gives no indicator to identify the presence of fractures. However according to Savadogo (1984), these fractures are present but are mostly masked at the base of alterites or merged with the base because of the small thickness.

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The relationship of flow-depth, allows noting that it has an influence on the productivity of structures, because the highest flows are obtained at relatively average depths (between 35 to 55 m). On the other hand, the statistical analysis coupled with the geophysics made it possible to show that, beyond 80m, the boreholes are much more likely to be negative. Thus, the depth of a work is not the guarantee of a large flow. The power of the alterations positively influences the productivity of the works. However, it would only be necessary for the alterations to be saturated and permeable enough to release the water they contain into a cracked underlying layer. In general, drillings implanted under more than 60 m of weathering have a flow rate higher than $4m^3$/h. From the geomorphological and hydrogeological point of view, to successfully drill in a basement area, it is essential to characterize the morphological potential such as depressions, escarpments, wadis and slopes and the flow zones, namely the sources or the, alluvial deposits, alignments in the vegetation. Indeed, the study of the fracturing makes it possible to appreciate the hydraulicity of the grounds prospected. Because the more of the area is fractured, the more the interconnection of fractures is more assured and the more the chance of encountering a productive fracture is high (Lasm, 2000). It aims to delimit the different geological formations and to highlight their hydrogeological role. The methodology applied for the processing of satellite images made it possible to map a set of lineaments in the Mongo area. The map developed has a high density of lineaments of varying sizes. This important density of lineaments as for it, highlights the different nodes of the fractures. These nodes, constituted by the intersections of the fractures, have significant water potentials.

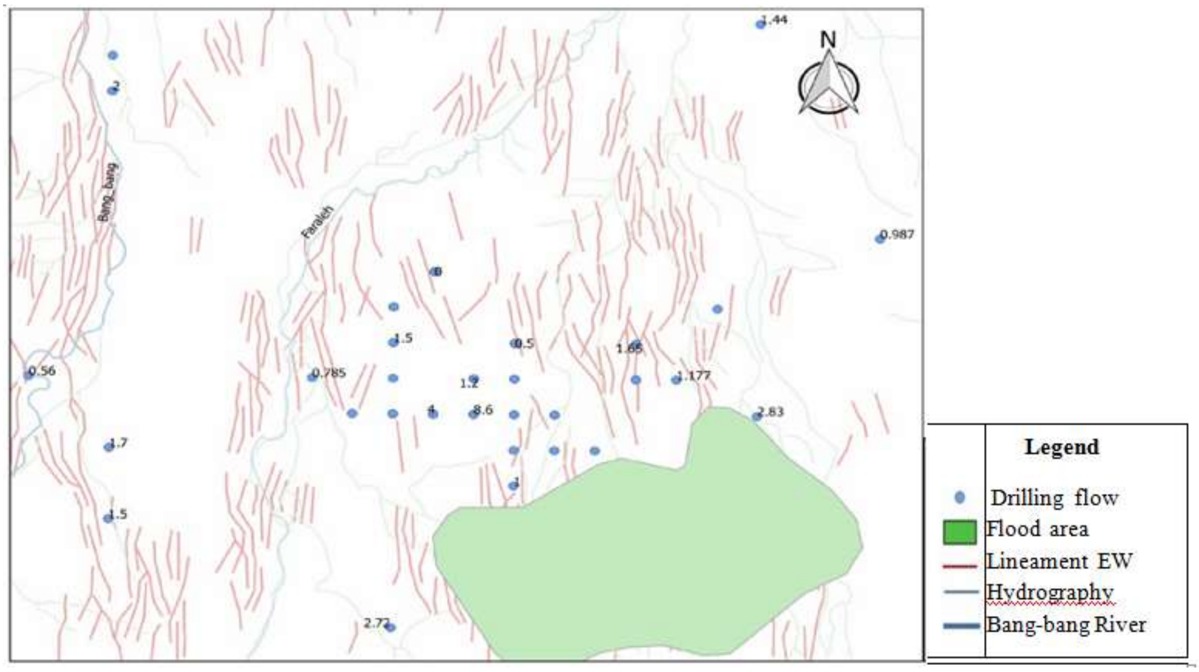

Figure 22: Breakdown of the flows on the map of the lineaments

V. CONCLUSION

The mobilization of water resources in the basement area in general, and mainly in the Guéra region, remains one of the major difficulties given the high evaporation leading to an early drying up of the wells in the reservoirs of alterites. The observed low flows could be attributed to the lack of knowledge of the parameters such as geology, and the parameters that can influence the productivity of the works in the area during its implementation. The different Landsat_8 image processing techniques and the SRTM images made it possible to map the lineaments. The application of the electric method (dragging and probing) in the field and the superposition of the productive boreholes of the database enabled the validation of some of these lineaments and then the identification of fractures that could constitute reservoirs. of water. The study of the productivity of the structures made it possible to identify the positive effect of certain parameters such as the static level and the thickness of alteration, on the flow of the structures. Thus, to ensure optimum flow of drilling in the basement area, the search for fractures or fracture intersections is recommended. Thus, in this study, several fractures with hydrogeological interests have been identified. The detailed map of fracture networks obtained is certainly not exhaustive but is representative of the fracturing of the study area. It will serve as a basis for the characterization of discontinuous reservoirs in the study area. However, in order to better understand the hydrogeological

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knowledge of the area and minimize the failure rate when drilling, it will be important to make a static and geostatic analysis of the fracture networks and couple these results with the hydrodynamic data of the area.

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