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Full Length Research

New approach of interpretive method of hydrogeological prospecting and electrical resistivity geophysics data: improvement of water drilling siting techniques in the field of crystalline soils of Burkina Faso (West Africa)

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This work is a contribution to the improvement of bore holes siting techniques through a new interpretative approach to hydrogeological and geophysical electrical resistivity prospecting data. Its objective is to make drinking water accessible to all through the reduction of negative drilling rates, which is very recurrent in the crystalline terrains of Burkina Faso.The main focus is on geophysical prospecting using the electrical resistivity method, which is the least expensive and most widely used in Burkina Faso and the West African sub-region. This work resulted in the construction of a framework for the interpretation of hydrogeological and geophysical prospecting data on electrical resistivity. The results obtained are very convincing despite a few cases of failure certainly related to the problem of ground water recharge.

Key words: Basement acquifers, flow, granitoïds, schists, alteration, geophysical surveys and geoelectric surveys.

INTRODUCTION

In Burkina Faso, in a general way, we are witnessing a resurgence of negative drilling rate. This could be explained in part by the absence or poor implementation of hydrogeological and geophysical prospecting techniques. The geophysical method of electrical resistivity, the least expensive of the geophysical methods applied to hydrogeology, is the most used by practitioners for the siting of water boreholes in Burkina Faso and in the West African sub-region. When they are sited on a site, they sometimes find several points they rank in order of preference. Very often, positive drills are obtained after drilling without success one or more of these points initially considered favorable. This generates huge costs for the applicants and makes it difficult for the beneficiary populations to have access to drinking water. We are thus witnessing a sort of trial and error in the interpretation and choice of the electrical soundings to be drilled. Some (Kouadio and Konan-Waidhet, 2015) have already addressed this problem and tried to provide solutions. But uncertainties always remain when it comes to making the best choice of sites to drill. On the other hand, other authors like Alle et al., 2015; even call for the abandonment of this geophysical method.However solutions can be made to reduce at best the failure rate of water drilling.It is with this in mind that our project of study which aims at making improvements to the techniques of sitting of water drills in crystalline soils by the geophysical method of electrical resistivity.

Our study was initially based on a statistical analysis of geophysical prospecting data and technical cutting of water drills, collected on a complete series of 227 wells drilled in crystalline terrain in the central and northern part of Burkina Faso. Then a comparative analysis of these data was made taking into account the lithology (granitoid, shale, crossed or not by veins of quartz or pegmatite). This allowed us to identify indicators to help select productive aquifer sites and to propose a new interpretative approach that could improve the success rate of sites to be drilled.

STUDY ZONE

Geographic location

Our study area is located in the central part of Burkina Faso including the Bam Lake watershed to study the parameters within a basin which is the basic hydrogeological unit. At the watershed of Lake Bam, there is very little research, data collection covers a larger area where the hydrogeological and climatic parameters vary little as shown in Figure 1. However, most parts of the verification and validation of the results obtained took place within this basin (Figure 13).

Geology

From a geological point of view, the area is characterized by two main lithologies, namely the greenstone belts intersected by the granitoids.

The Paleoproterozoic basement includes Birimian volcano-sedimentary and plutonic soils (2238-2170 Ma) arranged in belts and invaded by vast batholiths of ebony granitoids.

These belts consist of ultra basite beds, gabbro, diorite, andesite, rhyolite, rhyodacite, acid tuff and basalt dispersed in unequal proportions within a sedimentary and tuffaceous series generally schistose and verticalized . Green schistmetamorphism affected all of these formations, but amphibolite facies characterized by micaschists and quartzites, or leptynites and orthogneiss were identified near shear zones.

The granitoids are composed of batholiths divided into two sets: a tonalitic ensemble and a granite ensemble.

The tonalitic ensemble composed of quartz granodiorite, tonalite and, diorite, sometimes banded and foliated, intersects the volcano-sedimentary belts and Birimian plutonic belts. It is characterized by a quasi-continuous emplacement of plutons (from 2210-2100 Ma).

The Paleoproterozoic granitic ensemble occupies two thirds of Burkina Faso, crosses all terrains and is divided into two generations. First generation granites (2150 and 2130 Ma) superimposed on the internal tonalitic domain are often located along shear zones

They are mainly exposed to the east and north-west of the country. The main facies are biotite and often amphibole granite and banded heterogeneous granite.

Those of the second generation (2117 and 2095 Ma) form large batholiths (biotite / porphyroid granite) on both sides of the arched belt of Goren in the center of the country. They intersect the internal and intermediate tonalitic domains

Some masses of alkaline granites and late syenites (1889-1819 Ma) of small size outcrop scattered. Dykes and dolerite sills developed at the West African craton scale are found in both basement and sedimentary cover with N 80 ° W to N 60 ° W on the one hand, and N, NE at NS on the other hand (Casting et al, 2003).

Hydrogeology

The hydrogeological complexes of the study area are similar to those of the square degree of Kaya and Burkina Faso described by (Casting et al., 2003; Castaing et al., 2003; Egal et al., 2003).

Granitoïds

The granitoidgroup is divided into two subsets: the early granitoids and the late granitoids.

- Early granitoids were affected by many fractures with relatively high drilling success rates (70%) and significant flows for bedrock (10 m^3 / h or more). The thickness of the alterations is important.
- The later granitoids are not very fractured

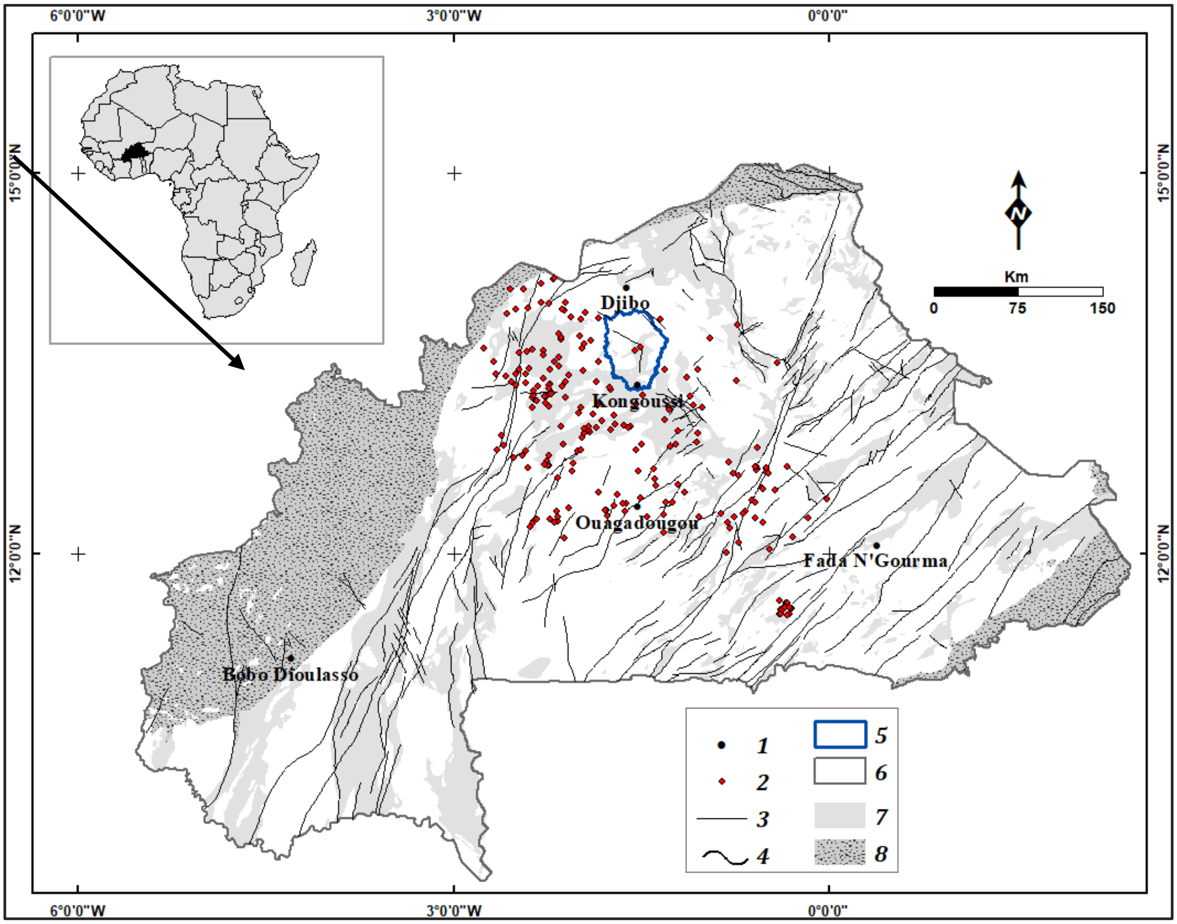

Figure 1. Geographical location and geological context of the study area: 1) Locality; 2) Data collection site; 3) Linear; 4) State limits; 5) Limits of the Bam Lake catchment area; 6) Granitoids; 7) Greenstone Belt 8) Paleoproterozoic Cover.

with the highest rate of failure of water drilling. The alteration is relatively unimportant.

Birimian schistose or volcano-sedimentary formations

These formations have generally significant alterites' thicknesses with a high success rate, up to 90% for manual pump drilling, a flow rate of about 0.7 m^3 / h. They are mainly found in the Kongoussi region. Alteration cover is important and sometimes saturated. These formations are often covered with a lateritic mantle whose aquifers are exploited by traditional or modern wells.

Sedimentary formations

They are alluvial formations that are limited from a geographical point of view. They generally consist of argillites, more or less sandy clays and the exploitation is most often made using temporary catch basins for market gardening. These formations are present along major rivers (alluvium) and their productivity depends on rainfall.

METHODOLOGY

Procedure The research methodology consisted of first, at defining the different types of geological anomalies, the forms of electrical anomalies on electrical surveys and the typologies of electric sounding curves. Subsequently, geophysical prospecting data precisely electrical resistivities and drilling parameters were collected and processed. These collected data mainly concerned the shape and the width of the anomaly, the type of electrical sounding, the thickness of deterioration, the flow,

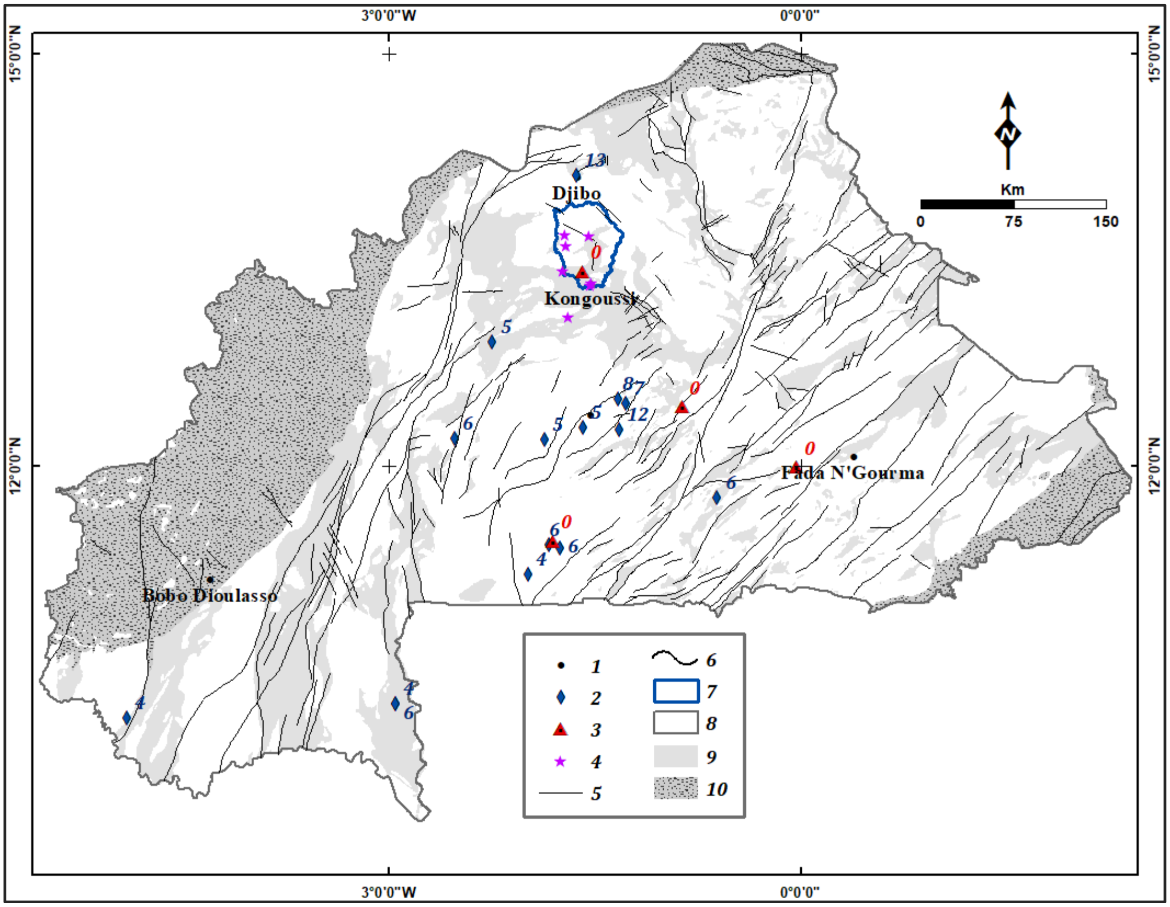

Figure 13. Site of verification of the results and application of the new interpretative approach: 1) Locality; 2) Application site successfully; 3) Application site with failure; 4) Verification site; 5) Linear; 6) State limits; 7) Limits of the Bam Lake catchment area; 8) Granitoids; 9) Belt of green rocks; 10) Paleoproterozoic coverage.

the static level, the lithology, etc.

The Schlumberger device has been used in geophysical measurements with sometimes different current line lengths depending on the site. Thus, this device has been tested to detect any variations and this, according to major lithologies (granitoids, basalt, and shale). At the end of the analysis, it appears that the shape of the anomaly varies very little according to the device used but its limits become less clear when the spacing between the electrodes of potential (MN) increases compared to that of Current injection (AB) (Figure 2 A, 2B and 2C). Thus, these criteria have been taken into account in the data collection.

Results from previous work (Millogo et al., 2018) have allowed us to better orient geophysical profiles and optimize work. A comparative study of the forms of anomalies, geoelectric probes, alteration depths, flow rates, and static levels according to the lithological context is made. It identifies the best indicators for making judicious choices when prospecting and interpreting geophysical data. Also a comparison between the intrinsic values of resistivities and the flow rates of the drillings is carried out according to the different devices used in the sampling (Figure 2D) to detect the links which exist between them.

Typology of anomalies

Three main types of electrical resistivity anomalies are frequently encountered (Dieng et al., 2004):

Driver' compartment type anomalies

These types of anomalies are found in fractured rocks and clearly, show a distinct conducting compartment. Depending on the width of the conductive area, the Large Conductor Compartment

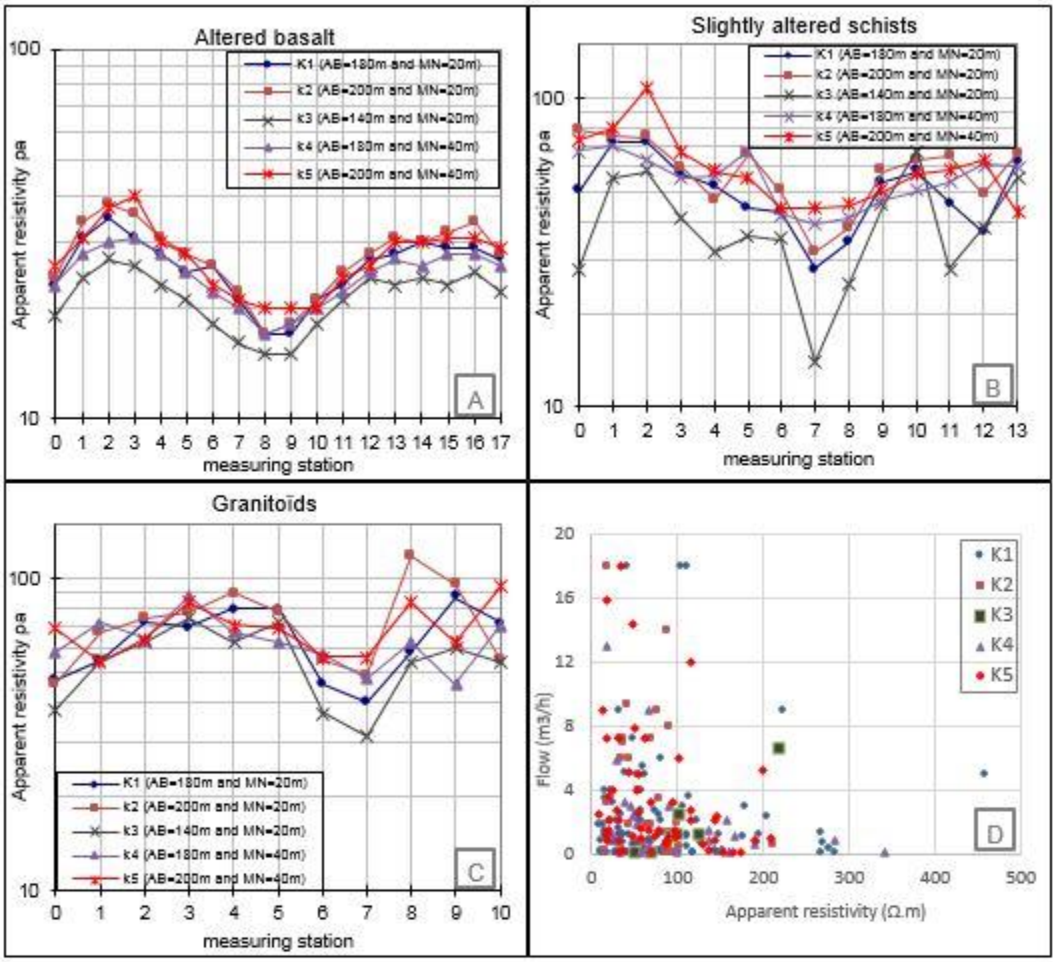

Figure 2. Study of the forms of anomalies according to different devices and geological context.

(CCL) is distinguished when the width of the conductive area is greater than 30 meters and the Narrow Conductor Compartment (CCE) for less than 30 meters.

Driver-grade anomalies

In this type, the anomaly is characterized by low values of resistivity of large width and poor boundaries.

Contact type anomalies between two bearings

Here, the anomaly is marked by the boundary between two formations having different levels of resistivity.

Forms of geoelectric anomalies

A total of seven forms of geoelectric anomalies have been distinguished (Figure 3):

- V-shaped anomaly that is pointed and can be isolated or not on a profile;
- U-shaped anomaly that is rounded and can also be isolated or not on a profile;
- W-shaped anomaly that is usually wide with a background disturbed by one or more resistors;
- K-shaped anomaly showing one or more pointed V-shaped conductors in contact;
- C-shaped anomaly showing no contact conductor;
- M-shaped anomaly that can be pointed (V) or rounded (U) and is framed by more conductive areas;
- H-shaped anomaly with a very clean conductive compartment and little disturbance by resistors.

Typology of vertical electrical soundings

This classification is based on scenarios encountered in three-field surveys. The most frequently

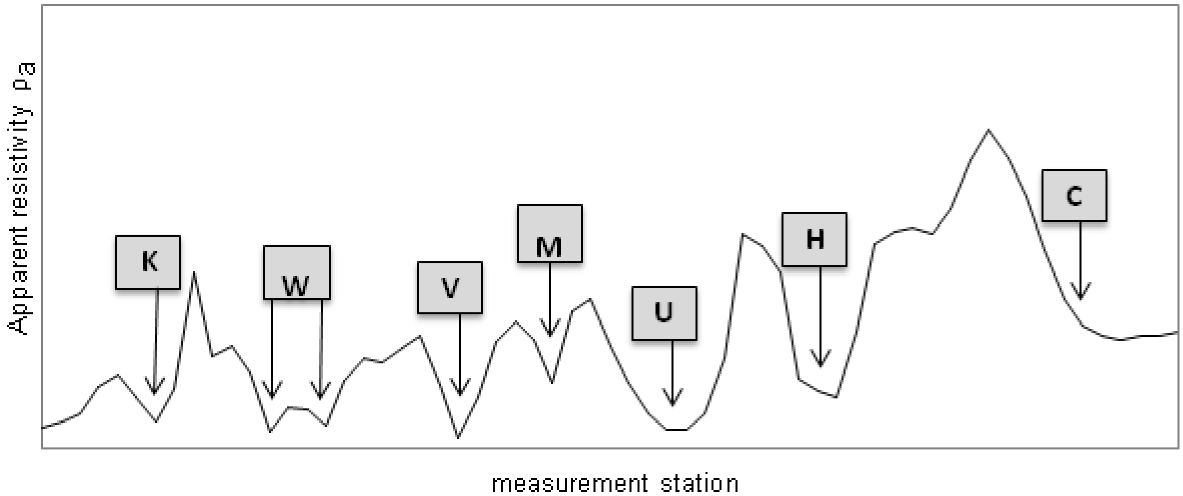

Figure 3. Example of forms of geoelectric anomalies of resistivity.

obtained electrical survey curve in the crystalline basement formations of Burkina Faso and its neighboring regions is a three-ground curve at the bottom of the boat (Savadogo 1984).

For survey cases with more than three lots, a combination of different types is required. Figure 4 shows the different types of electrical soundings:

H-type sounding with the conductive ground between two resistors. It is characteristic of lands covered with lateritic cuirass. The curve has a boat bottom representing the conductive complex of low resistivity. Very low values of resistivity are often indicative of the presence of wet and fluent clay. These clays can be a handicap when drilling. The rise of the curve at 45 ° corresponds to the base very little or not cracked (Figure 4A).

K-type sounding with a resistant ground between two conductors: this is the bell curve. The overlying layer of soil is most often composed of sand-clay overlay (Figure 4 B).

A-Type sounding with resistivities that increase stepwise. It can often have one or more inflections characterizing a sometimes wide conductive bearing. Observations made on drill debris indicate grained arenas with interesting storage properties (Figure 4C).

Q-type sounding with decreasing resistivities. This type of curve indicates less resistant terrain at depth. There is often a plateau between the first resistant ground and the second more conductive ground. This landing often corresponds to the roof of the sheet of drowned cuirasses. Field observations, in particular biological indices and many wells, determine the presence or absence of this layer (Figure 4D).

KH-type sounding represents a bell curve followed by a curve in the bottom of the boat. It is characteristic of four (04) hole surveys (Figure 4 E).

It is important to note that, depending on the type and number of terrains, these curves of electrical sound curves can be quite complex. Incomplete soundings do not show a rise to 45 ° indicating a very deep sound base not reached by deep investigation (4B and 4D). This case is very common in shale soils where very long AB line lengths are required to reach the healthy basement covered by a large thickness of alterites or in molassic sandstone with conductive substratum (Chapellier, 2000; Koussoubé and al., 2003).

RESULTS AND ANALYSIS

Typology of geoelectric anomalies

In our sample, the CCL anomalies were the most represented followed by the CEC type. The PC and CEDP anomalies were very small and therefore not representative (Figure 5A). Thus, only CCL and CCE type anomalies were retained for further analyses. Figure 5B summarizes the results of the analysis of success rates according to the type of anomalies and the lithology. Regardless of the type of anomaly (CCL or CCE), the success rates of drilling operations are slightly higher in shale than in granitoids.

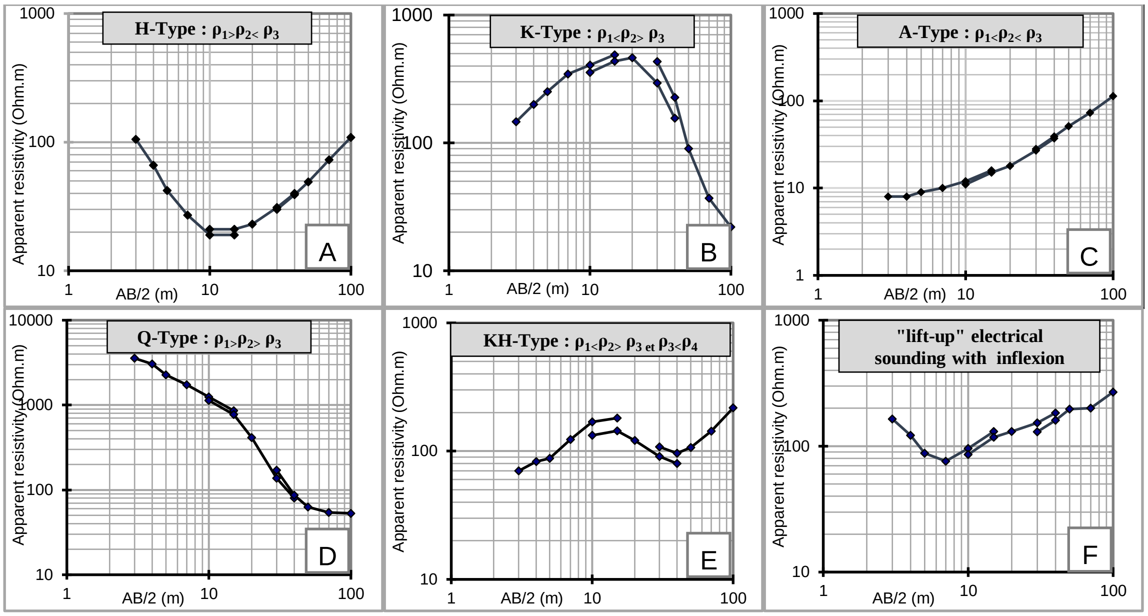

Figure 1 . Typology of electrical soundings encountered.

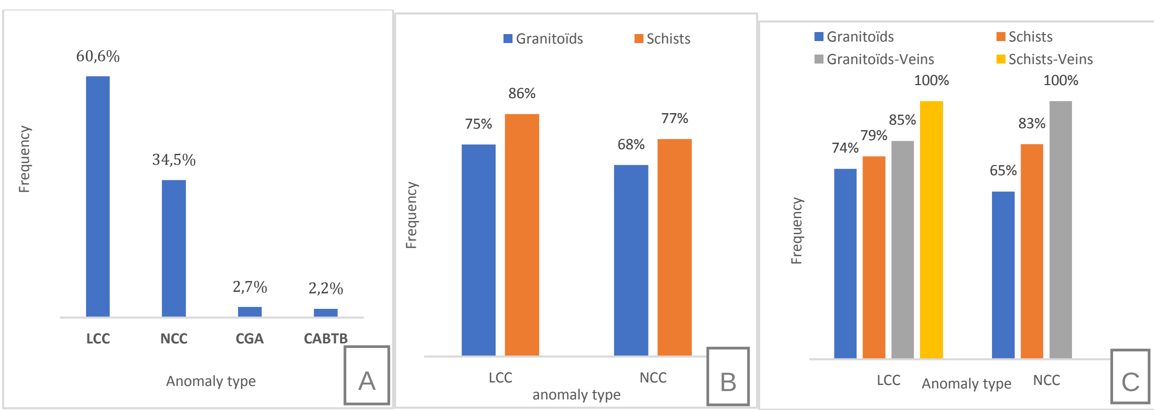

Figure 2. A) Anomalies types frequency; B) Anomalies types frequency as a function of the width of the conductor corridor and lithology; C) Anomalies types frequency as a function of the width of the conductor corridor, lithology and the presence or absence of quartz or pegmatiteveins

By separating the granitoids and schists crossed by veins of quartz or pegmatite from those not traversed, the success rates in veined cut granitoid and shale improve in CCE-type anomalies to the detriment of CCL-type anomalies. These rates are close to 100% in shale intersected veins for CCE anomalies. It should be noted that the improvement or not of drilling flows for CCE anomalies in schists traversed by quartz or pegmatite veins could not be verified because this sample was not sufficiently represented.

Forms of anomalies on the electric tow curve

At the level of electric tows, V, U, W and K-shaped anomalies are the most represented. The forms C, M and H are very poorly represented and in proportions of less than 5% each. This is partly explained by the fact that most prospectors favor form anomalies V, U, W and K to the detriment of other forms. Only these four forms V, U, W and K were selected for further study (Figure 6A).

In the granitoids, the U-shaped geoelectrical

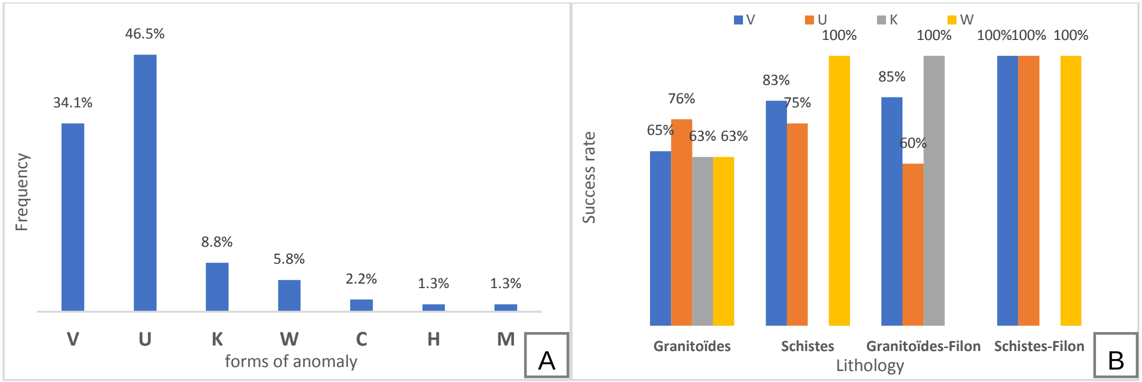

Figure 6. Frequency of anomalies according to the form of the anomaly; Success rate according to lithology.

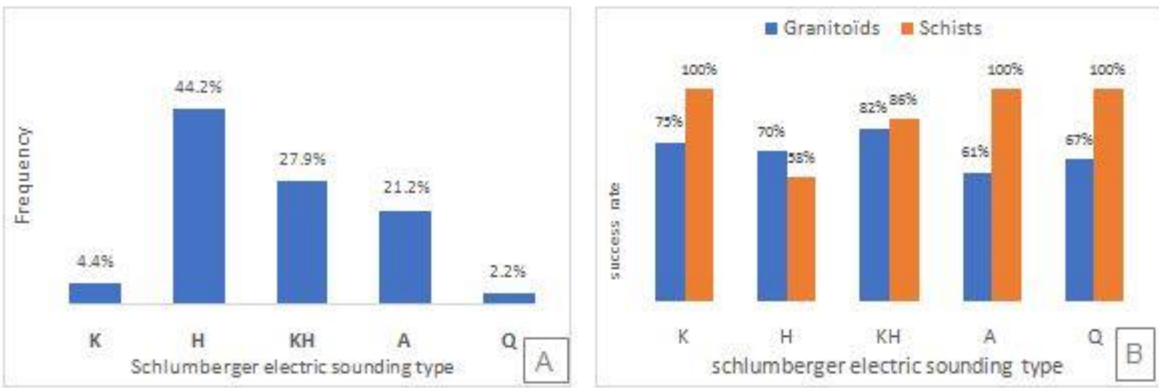

Figure 7. A) Frequency of types of electrical soundings; B) Success rate according to the type of electrical survey.

anomalies give better results (76%) as against 60% for the V form and 63% for each of the W and K forms. On the other hand, in the schists, the best results are obtained with Form V (83%) and W (100%) defects. The presence of quartz vein or pegmatite in the granitoids improves the success rates of form V (85%) and K (100%) anomalies, but the opposite effect is observed with U-shaped anomalies (60%). There is a clear improvement in the success rate of around 100% for V, U and W anomalies in schists traversed by quartz veins or pegmatite. There is also a total absence of K-shape anomalies in shale sites with or without vein presence. Also, the success rate of the W-shaped anomalies could not be verified in the granitic terrains traversed by veins (Figure 6B).

Typology of electric surveys curves

The statistical analysis of the data shows that the H, KH and A sample are the most represented (Figure 7A).

In this analysis, the distinction between the presence or not of quartz veins and pegmatite has been made in view of the reduced sample size. Only the distribution of the types of electrical survey curves between shale and granite was retained. Overall, for all the electrical drill curves, the success rates are higher in the shale than the granitoids and often reach 100% even if the reverse is found only in the H-type soundings (Figure 7B).

The electric sounding curves can be divided into two (02) groups. On the one hand those presenting rise to 45 ° and on the other hand that having an inflection therefore to "dragging up". The results show that drill holes on "lift-up" electrical sounding curves have higher success rates than those on non-inflectional sounding immediately up to 45 ° and those without lithological distinction. This inflection has no major influence on the productivity of KH type surveys. On the other hand, it becomes an appreciable indicator for type H and especially A

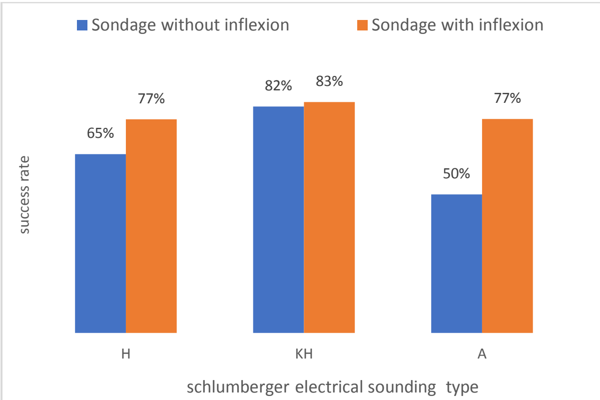

Figure 8. Success rate of electrical surveys with inflexion or without inflexionat the upturn.

surveys, where it contributes to improving the success rate by around 25% (Figure 8).

Best combinations of dragged curves and electrical surveys

In order to push the analyses, a combination was made between the different forms of Schlumberger tow curve and electric survey type anomalies. The purpose of such an analysis is to determine which combinations are likely to produce the best success rates and those based on the geological facies. For all two (02) main facies (granitoids and schists), the combinations between the different forms of anomalies and the K and Q electrical soundings have not been analyzed because they are not very well represented.

In the granitoids, the combinations between the H-type sounding and the various forms of anomalies V, U, W and K give results that are appreciably close to 69-76%. These results improve when KH-type sounding is associated with V, U, and W shape anomalies of the electric train. On the other hand, a success rate of 76 to 50% is observed when the KH-type sounding is associated with the anomaly of form K. There is a considerable improvement by associating the type-A sounding with the anomaly of form K on the one hand and the Q-type sounding on the form V anomaly. The combination of the KH-type sounding and the W-shape anomaly, which has a very high success rate, decreases when the sounding is replaced by type A. Less good results are also obtained for Type A probing associated with Form V and U anomalies, unlike Type H and KH probes (Figure 9A). For all shale soils, the K-shaped anomalies were totally absent, the analysis only concerned the V, U and W forms. Like the granitoids, the success rates improve when we go from the H-type electric sounding obtained on form V and U anomalies to the KH sounding. The success rate of the H and KH soundings obtained on the W-shape anomaly remains unchanged. The combination of type A probing with form V and U anomalies gives the best results close to 100% in contrast to granitoids. The association of the Type A sounding with the W-shape anomaly could not be verified for non-representativity (Figure 9B).

At the end of the combinatorial analysis, a framework for evaluating the success of a borehole based on lithology and geophysical data was constructed (Table 1). This framework built on the basis of the statistical study is not exhaustive and could vary in a different geological or climatic context. In addition, certain parameters like the depth of deterioration, the global static level in zone, the topography could influence these results.

DRILLING PARAMETERS

Alteration thickness

The analysis of the diagram below shows that the best flow rates are obtained in both granitoids and schists. But there is no well-defined correlation between flow and depth of weathering (Figure 10A and 10B).

In the granitoids, the success rate increases with the depth of alteration but beyond 40 meters, this trend is no longer verified. However, in schists, the best flows are obtained regardless of the depth of weathering.

Correlation between depth of alteration and first arrival of water and the static level

A slight linear correlation is drawn between the depth of alteration and that of the first waterfall according to the correlation coefficient which is 20% on the granitoïds and 30% on the schists (Figure 11A). In fact, the first influx of water generally appears at the base of the alterites, which often corresponds to the grainy arena. These arenas are very productive if the diet is good.

However, there is virtually no significant correlation between the depth of the first inflow of water and the static level (Figure 11B). This means that the overall static level of a given area cannot be considered as

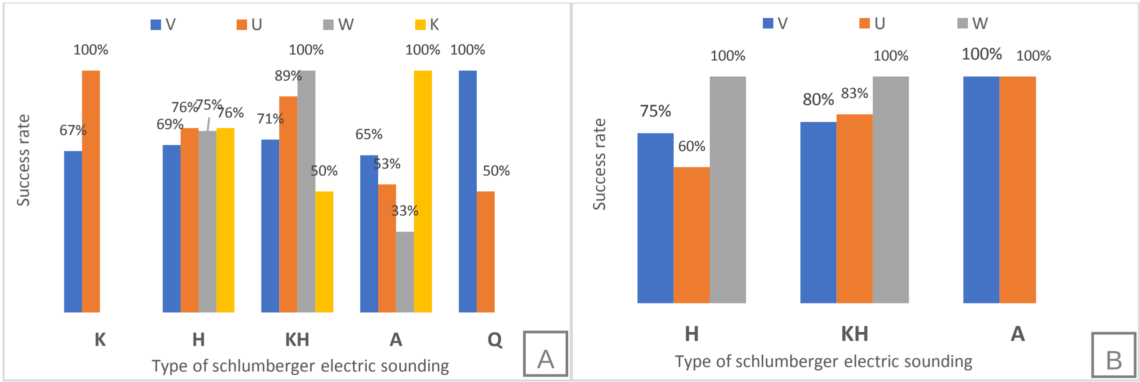

Figure 3. Success rate of combination of typology of trailing and sounding forms A) Granitoid and B) Shale.

Table1. Success rate based on combinations of electrical anomaly patterns and type of Schlumberger electrical survey curves.

Lithology	Forms of tow curve anomaly	Type of survey curve				
		H	KH	A	K	Q
Granitoïds	V					
	U					
	W					
	K					
Schist	V					
	U					
	W					
	K					

LEGEND

- Not determined
- Below 40%
- 40-60%
- 60%-80%
- Above 80%

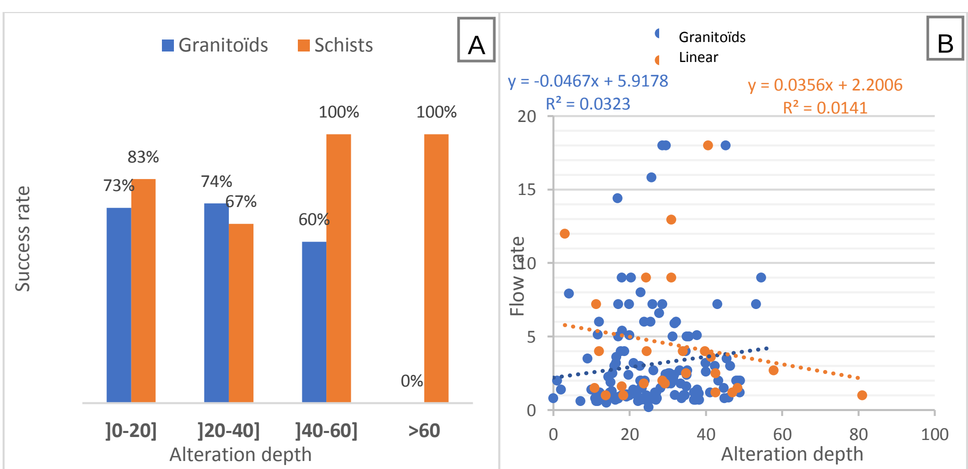

Figure 10. A) Success rate according to the depth of the alteration; B) Correlation between flow and alteration.

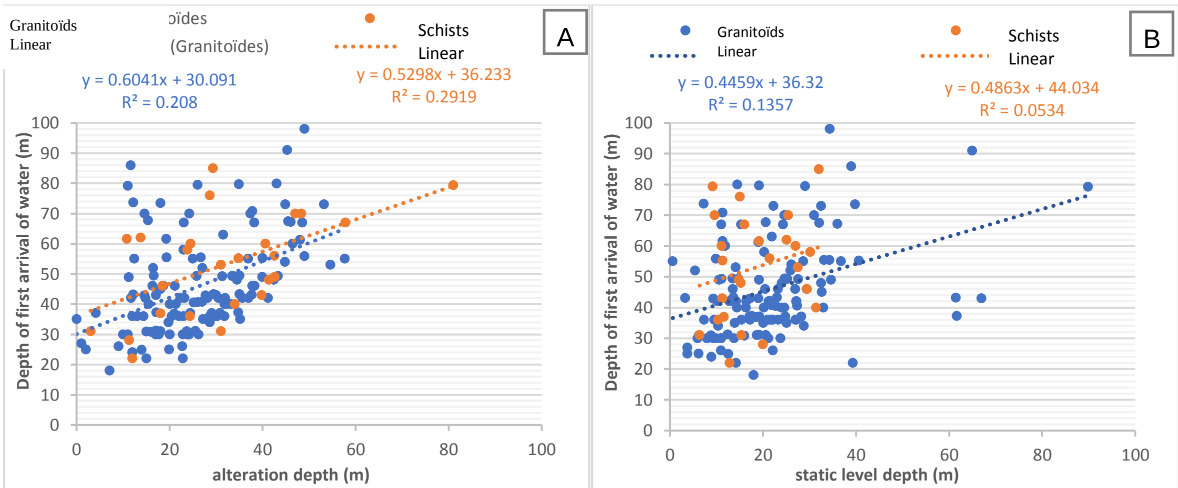

Figure 11. A) Linear correlation between the depth of the first arrival of water and alteration; B) Linear correlation between the depth of the first arrival of water and the static level.

the depth of the first waterfall. Information worthy of interest when choosing the point to be drilled.

Inconsistency between alteration thickness resulting from electrical soundings and geological cuts of boreholes

The analysis of the data shows a difference between the theoretical alteration thicknesses deduced from the electric sounding curves and the real ones from the boreholes. An evaluation of this difference was made by making the difference between the theoretical alteration thickness and the actual alteration thickness (Deviation = Theoretical Threshold Thickness - Actual alteration Thickness). A positive difference means an overestimate of the thickness and a negative difference an underestimate. So the theoretical thickness is realistic when the gap is close to zero.

The calculated alteration thickness differences show that these are not related to the geological context. The analysis shows that the difference between the estimated and actual alteration thickness over all the drillings and then only the positive drillings can be greater than 20 meters, especially in the shale terrains. Nevertheless, the overall frequency of these differences remains low and less than 20%.

Validation of results

The results from the above analyzes were subject to verification in the field. Thus, we have identified some of the high-volume boreholes used for drinking water supplies for validation measures of the results obtained. Some of these boreholes are those used for the drinking water supply of the populations of Bourzanga, Rollo, Gondékoubé, Temnaoré, Koudoula and by the ONEA (National Office of Water and Sanitation) for the supply of the populations of Kongoussi in drinking water. These boreholes of flow varying between 7 and 18 m^3 / h are distributed between granitic, basaltic and schistous soils representative of all the crystalline basement terrains of Burkina Faso. The geoelectric anomaly pattern and drill pattern combinations obtained are those with success rates ranging from 60 to over 80% according to the pattern indicators (Table 2).

At the end of the validation phase, the success indicators were applied to the choice of points to be drilled during various campaigns to install water wells throughout the crystalline basement areas of Burkina Faso. This resulted in high success rates of around 80% (Figure 12). However, cases of failure have been noted. The analysis of the cuttings of these boreholes highlights the frank altered and fractured but which are found to be very little or poorly fed.

DISCUSSIONS

The choice of measuring device can influence the pace and shape of the anomaly. Indeed, the limits of the anomalies become less clear when the spacing of the receiving electrodes MN becomes large compared to the spacing of the injection electrodes

Table 2. Results of validation measures.

Site	Géologie	Anomalyform	Typology of the survey curve	Alteration	Operating rate
FK16 (ONEA Kongoussi)	Altered basalt	V	KH	70 m	10 m^3/h
FK10 (ONEA Kongoussi)	Altered basalt	U	A	40 m	8 m^3/h
Rollo	Granite	V	H withlift-up	30 m	7 m^3/h
Gondekoubé	Granite	V	H	41 m	18 m^3/h
Temnaoré	Schist	U	K	85 m	9,3 m^3/h
Koundoula	Schist	W	K	15 m	20 m^3/h
Bourzanga	Schist	V	H withlift-up	9 m	9 m^3/h

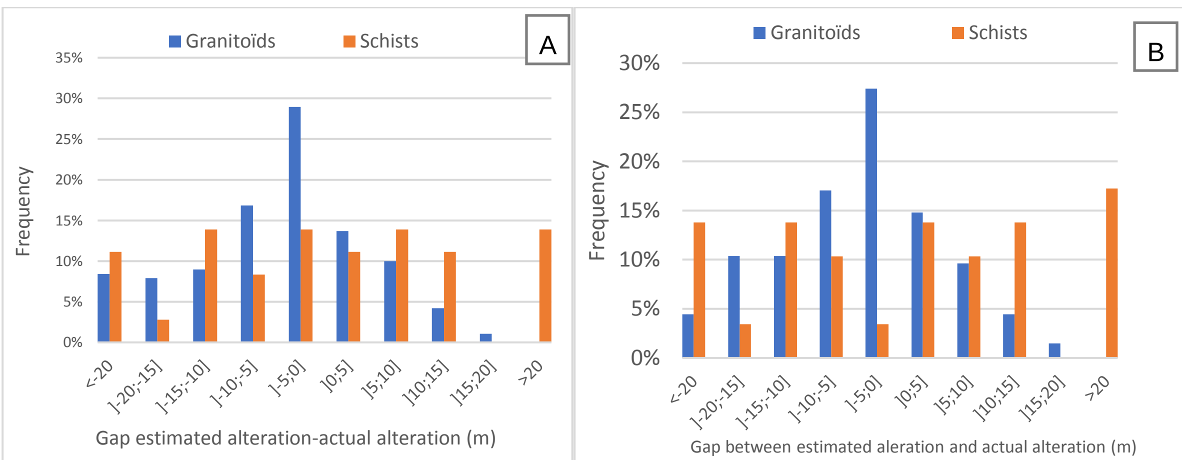

Figure 12. A) Frequency of the difference between estimated and actual alteration for all drillings; B) Frequency of difference between estimated alteration and actual alteration for positive drilling only.

of the current AB. It would be best to choose the line length AB as a function of the approximate depth of the fractured fringe and MN sufficiently small relative to AB. The determination of the crack free depth of a given zone can be made from geoelectric surveys carried out on pre-existing boreholes.

Overall, the success rate of water drilling in shale is higher than in granitoid rocks. But the presence of quartz vein or pegmatite improves this rate regardless of lithology. Most quartz and pegmatite veins were ejected and / or milled to promote circulation or storage of water. When the vein is only ejected and unmilled, it is very difficult to locate productive contact accurately from geophysical resistivity methods, sometimes resulting in negative drilling implementations. The increase in the success rate of CCE-type anomalies with respect to CCL in vein granitoids may be reminiscent of drillings positioned on the contact aurole of ejected veins which are generally small and highly productive than the vein itself. Even when it is not crushed. In volcano-sedimentary terrains (altered basalt or shale), the flow of many of the boreholes is reduced by the clogging of the pore in the immediate environment of the drilling by fine particles. It is sometimes enough to make a new borehole close to less than ten meters to find the speed of yesteryear which will eventually drop too. This phenomenon has been observed on the boreholes exploited by ONEA in volcano sediments in Kongoussi.

The results obtained corroborate the work of (Dieng et al., 2004; Koussoubé et al., 2003; Nakolendoussé, 1991; Savadogo, 1984) and allow in addition to having a framework to help choose the best productivity sites. For the judicious use of this framework, other hydrogeological, geomorphological and other data should be associated.

The analyses also show that the positive holes are implanted both on low resistivity values and on large ones. Nevertheless, there is a trend that the majority of boreholes with a flow rate greater than $5m^3$ / h have anomalous values of less than 100Ω.m in both crystalline and schistose terrains (Figure 2D). It is important to note that the intrinsic value of resistivity cannot in itself constitute an appreciable decision criterion in the implementation of a drilling. However, the form of the anomaly is a criterion of choice and we recommend that the choice of the forms of anomalies be preferred according to the characteristics defined in Table 3.

After the choice of the anomaly forms on the electric tow curve, another appreciable additional criterion to be taken into account is the typology of the geoelectric sounding curve. The types of geoelectric probes to be preferred depend on the shape of the anomalies and the lithology as indicated in Table 1.

Nevertheless, whatever the lithology and the form of the anomaly, "upstream treatment" surveys should be preferred. The drag is a conductive landing that can be arena or cracked frank. It can be located just below the alteration or clay arena or between two healthy compartments (inclined fractures or horizontal fractures). When the recharge conditions are met, these curves "upward drag" can give significant flow on the granitoids as was the case in Koubri (12 m^3 / h) and Djibo (13 m^3 / h). The impact of the lift is very important, especially on type A surveys where it improves the success rate by around 25%.

The depths of theoretical alterations deduced from the sounding curve do not always coincide with those obtained on the boreholes. Deviations can sometimes reach 20 meters especially in shale terrain. However, if the choice of the types of anomalies and the type of electrical survey have been made judiciously, these differences will have less influence on the success rate.

On the whole, the results obtained are satisfactory despite the cases of failure certainly related to the problem of recharge. There are cases where geological data is totally different from geophysical data. Indeed, a geological section may differ from a geoelectric section when the boundaries between the geological layers do not coincide with the limits deduced from the resistivity values (Chapellier, 2000). Thus, a geoelectric sounding curve may correspond to different distributions of resistivities and to thicknesses leading to erroneous interpretations and consequently to negative water drilling implementations.

CONCLUSION

This work made it possible to identify, from geophysical databases and drilling parameters, geophysical indicators that could improve the success rate of water wells. This led to the construction of a framework for the interpretation of hydrogeological and geophysical prospecting data for electrical resistivity. The results obtained were conclusive during verifications on productive boreholes. The use of the framework in interpreting the data on new implantations has yielded interesting results even if a few cases of failure have been encountered. These cases of failure are related to the bad or total lack of water supply at the level of the anomaly. Today, the major challenge is the problem of groundwater recharge. As a perspective, we plan to work on a larger database and also address the issue of groundwater recharge with a view to further improving the success rate of water drilling installations.

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