DETERMINATION OF GROUNDWATER AQUIFER TYPES BY GEOLOGICAL APPROACH :

CASE OF THE COMMUNE OF AMPITATAFIKA ANTANANARIVO MADAGASCAR

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ABSTRACT

In the uplands Malagasy, specifically in the Analamanga Region, access to drinking water seems to be difficult due to outdated installations and a lack of new water connections, particularly in the peripheral areas of the town.

The majority of households in Ampitatafika Antananarivo opt for well water as their water supply solution. As a preliminary study for further research work, a geological and hydrogeological knowledge base of the area is to be determined for sustainable exploitation of the underground water resource.

The aim of this article is to identify aquifers. The combined geological, hydrogeological and geophysical approach consists in determining the lineaments by satellite image processing, then interpreting a geoelectric section of the area to specify the lithology of the terrain in order to determine the characteristics of existing aquifers.

The results concluded that there are two types of aquifer at Ampitatafika: an alterite aquifer and a fractured basement aquifer.

Keyword *: geology, lithology, geoelectric, aquifer, water.*

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1. INTRODUCTION

Drinking water can be obtained from surface water and groundwater, both of which are available on the Antananarivo plain and its outskirts [4]. Although the quantities available are limited to future needs, the exploitation of groundwater resources is not excluded.

Groundwater can be used for any purpose [3]. A geological and hydrogeological study is essential to determine the existence before exploitation of water needs and demands to be served in a given area [1] [2] [4].

In the outskirts of the Analamanga region, since 2009, around 66.3% (Ministry of Water Madagascar) of the population still rely on groundwater (wells, water towers, resurgences) for their drinking water supply. Among other things, the use of groundwater helps meet the needs of Madagascar's peripheral capital zones, as used by the majority of households in the commune of Ampitatafika. However, living close to the city is becoming more and more of a trend. Demographic growth, rapid urbanization and industrial development are all rapidly increasing the demands on groundwater resources.

In this sense, a preliminary study leads to the objective of this article, which is to identify aquifers. The approach consists of a geological, hydrological and geophysical study of the Ampitatafika commune to determine the characteristics of existing aquifers. This constitutes good management of water resources in a sustainable way.

2. MATERIALS AND METHODS

To do this, identification involves identifing for aquifer areas. The objective is to describe the lithological nature of the aquifer system: roof, reservoir and floor, as well as the location of aquifers. However, a morpho-tectonic study (fault networks or structural analysis, etc.) is also required [2] [3] [4].

Understanding the structure and functioning of the aquifer system requires a multidisciplinary study [3]. To achieve this, we use combined geological, hydrological and geophysical prospecting [5]. The prospecting method involves confronting information from satellite image processing with a geoelectric cross-section of the subsoil in the study area [6].

2.1 Study area location

The study area is the Ampitatafika Rural Commune (cf Chart-1). The Municipality is located in the Analamanga Madagascar Region. It belongs to the District of Antananarivo Atsimondrano and is located at more than 1,200 m above sea level, spread over an area of 21 km². Its neighboring municipalities are in the North the Itaosy Rural Commune – Andranonahoatra, in the South the Alatsinainy Ambazaha Rural Commune -Androhibe, to the East the Rural Commune Anosizato West and to the West the Rural Commune Fenoarivo -Alakamisy.

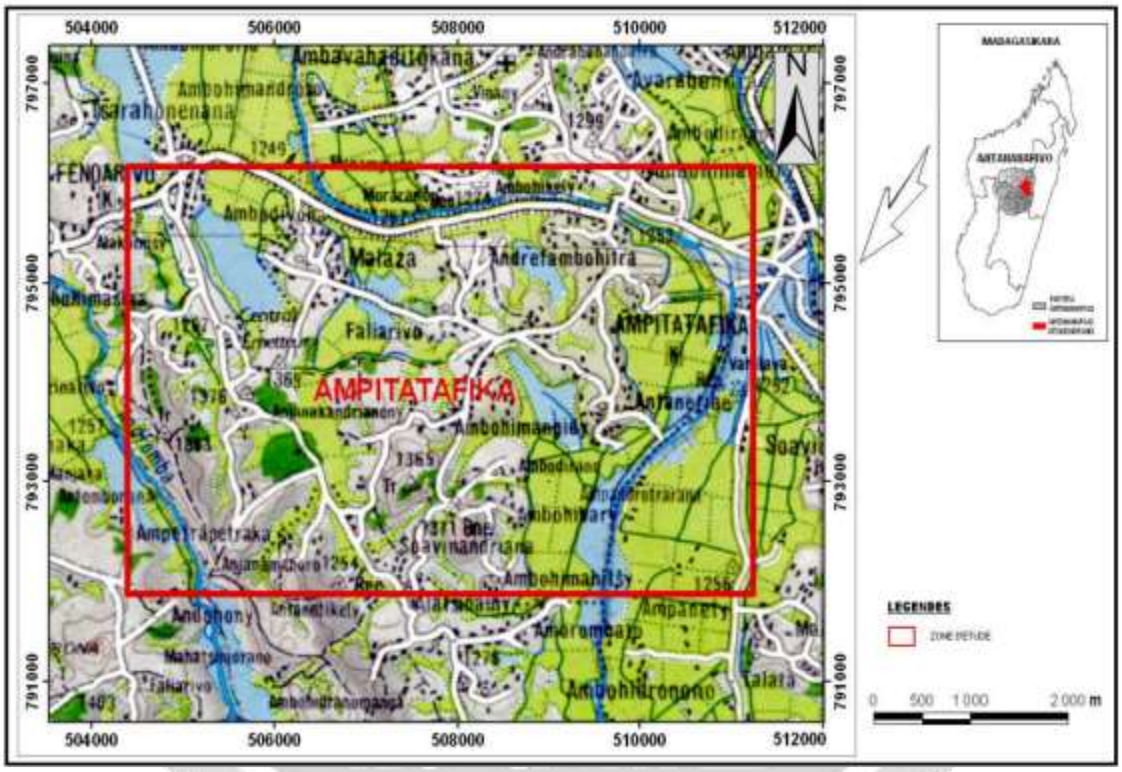

Chart -1: Geographic map of Ampitatafika-Antananarivo

2.1 Geological prospecting

In our study, geology is the basis for groundwater prospection. For this reason, the regional geological map of the study area illustrates a good knowledge of the local geological formation, both in sedimentary terrains and in basement zones with discontinuous aquifers. It is combined with a morphological and tectonic map to help identify the lithology of the subsoil, the location of the reservoir and the nature of the aquifers. This study provides essential information on groundwater [2] [3] [4].

2.2 Hydrological prospecting

Reconnaissance drilling (of wells or trenches) is carried out solely for the purpose of hydrogeological prospecting, and not for exploitation. Depending on conditions and objectives, it can be carried out quickly and economically, or very carefully. In addition to geological observations and geophysical calibration (or even reinterpretation of data already acquired) [6] [9] [10] [11], it will enable us to identify the aquifer, mainly the following elements:

- confirm and clarify the hypotheses put forward in the literature review
- nature of the aquifer, etc.

2.3 Remote sensing

Remote sensing is the set of methods and techniques for acquiring, processing and interpreting images of the earth's surface, obtained from the study of electromagnetic radiation, by airplane or satellite [7].

In our case, the LANDSAT ETM 7+ 159 073 satellite image of the area was processed using Envi4.7 software before being interpreted. From the combination of 70-40-20 bands, we obtained a false-color image that highlights the different types of tectonic deformation (brittle and soft deformations). The lineaments are plotted in ArcGIS 9.1.

2.4 Electrical methods

Electrical methods are based on measuring the resistivity of geological formations. Geological formations very often have specific resistivities that remain approximately constant, at least locally, whereas they vary considerably from one formation to another [8] .

Electrical imaging is a technique for electrical prospection of the underground. It enables both vertical and lateral investigation in two dimensions (2D). We chose the Wenner device. This is the device with all electrodes aligned and equidistant from each other (AM=MN=NB=AB/3=a).

PROSYS software records and filters the digital soil resistivity data acquired, combined with topographical data.

The RES2DINV program (developed by H. Loke in 1995) is used to invert data acquired in the field into a 2D model of the subsurface called a "pseudo section". The software then automatically inverts the pseudo section models into an interpretable 2D true resistivity model. The result is a geoelectric cross-section of the subsoil, showing the 2D distribution of true resistivities and, in favorable cases, enabling the location of aquifers to be deduced.

Interpretation of the geoelectric cross-sections of the Ampitatafika subsoil showing the 2D distribution of true resistivities enables us to determine the location of the aquifer and to describe the lithology of the terrain in order to deduce the types of aquifer. We chose an electrical panel profile taken in Fenoarivo, as the commune is close to our study area and the geological formation is the same. It is therefore representative of the area. The panel profile overlaps two different formations from north to south of Fenoarivo, orthogneiss and alluvium (Source: SGDM).

3. RESULTS AND DISCUSSIONS

3.1 Satellite image analysis

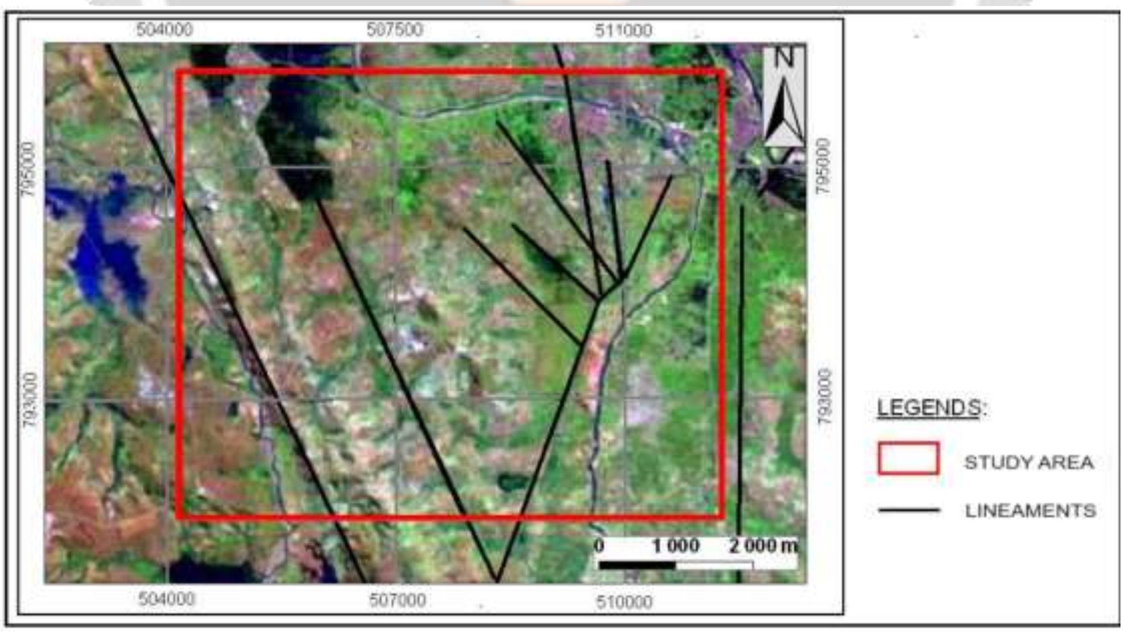

Chart -2: Lineaments map of the Ampitatafika zone

This colored composition (cf Chart-2) reflects reality through its coloring (vegetation: green, soil: red and hydrographic network: blue). The study area has a highly fractured basement. Lineament directions are generally N-W/S-E, probably corresponding to fractures. They are interconnected.

3.2 Geoelectric model of the Ampitatafika subsoil

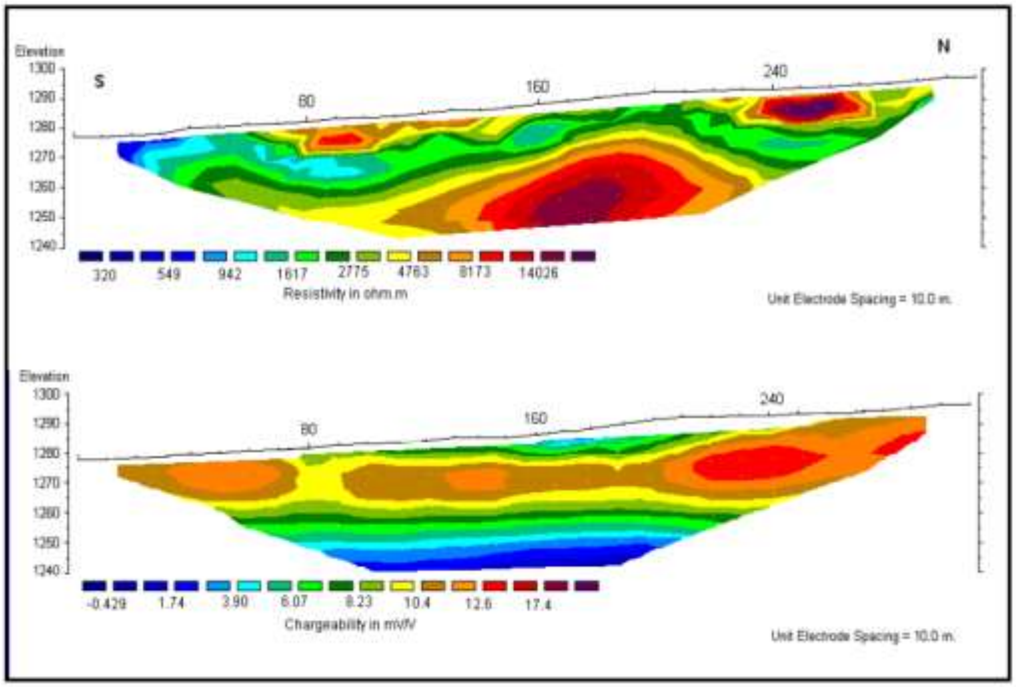

Chart -3: Ampitatafika geoelectric section

The geoelectric section of the panel (cf Chart-3) shows three formations:

- a resistant surface formation with an electrical resistivity of between 2,500 and 9,000Ωm, corresponding to a lateritic cover. It is represented by the color yellow to red. Its boundary lies between x=70 m and x=150m.
- a first formation is represented by the blue color enveloped by the green formation. It is conductive because its resistivity range is between 320 and 900Ωm with high chargeability. Its limit is between the beginning of the profile at x=100m, x=160m, and x=240m, while the layer enveloping it covers the profile from beginning to end. It is approximately 8m thick. It may correspond to an alteration aquifer.
- the second formation is resistant, ranging in color from yellow to red, with resistivity varying from 2500 to 9000Ωm. Its average thickness is around 10m. It almost covers the profile at an altitude of 1260m above sea level. It may correspond to altered orthogneiss.
- a final resistant formation, 9500 to 15000 Ωm in size, with low chargeability and a red to violet color. Its lateral extension is between x=140 and x=210m. It is outcropped between x=240m and x=270m. It forms the bedrock. Geologically, it corresponds to bedrock.

3.3 Geological synthesis

The geological context of the Ampitatafika area is represented by lowlands and alluvial plains generally covered by a lateritic weathering cover and dominated by E-W-trending reliefs resulting from neo-tectonic phenomena of crystallophyllian vertical movements and weathering/erosion processes. It rests on the metamorphic Precambrian crystalline basement (cf Chart-4).

Based on the analysis of previous satellite images (cf Chart-2), the area features lineaments that are indicative of fractures that could also contain significant aquifers. Aquifers in the study area can therefore be divided into two categories: those in the alterites and those in the fractured basement.

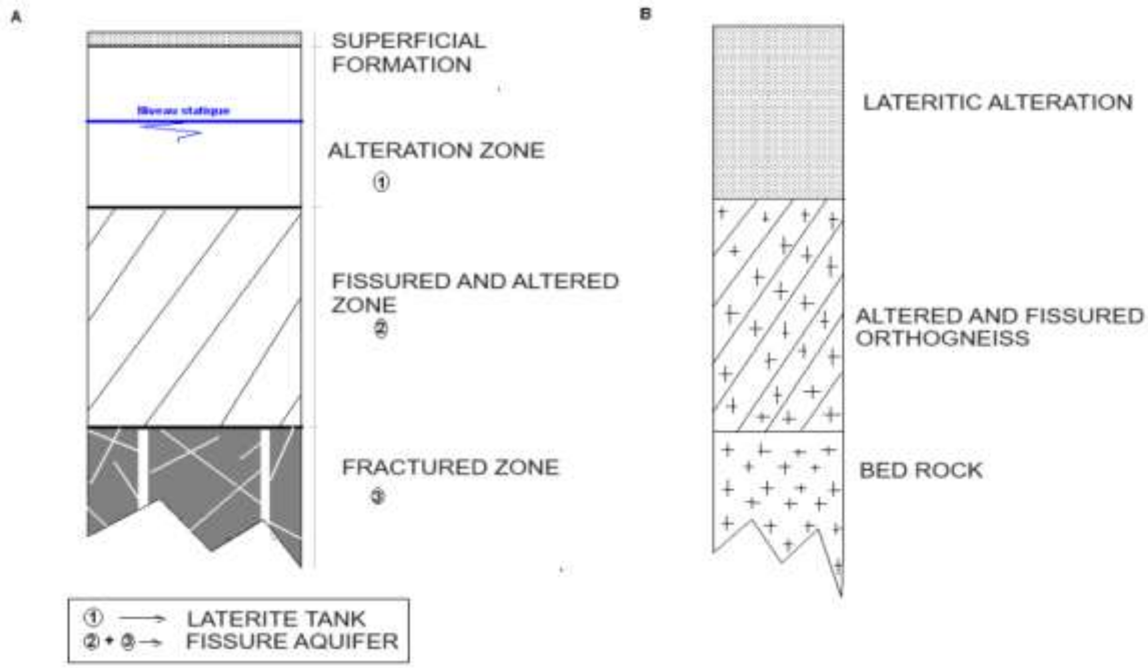

Chart -4: Conceptual model of different aquifer systems (A) and Ampitatafika lithology (B)

4. CONCLUSIONS

The study identified the formation of the study area, which consists of Precambrian metamorphic fractured crystalline basement and alluvium formed by orthogneiss, overlain in places by lateritic alteration.

Then, interpretation of satellite imagery led to the identification of a highly fractured basement, with lineament directions generally N-W/S-E. The fractures are interconnected.

Finally, the geophysical study provides a model of the lithological superposition and type of aquifer. In conclusion, a groundwater table in the alterites and a groundwater table in the fractured basement have been identified.

However, this study calls for long-term hydrodynamic, hydrochemical and microbiological monitoring of the study site in order to characterize the Ampitatafika aquifer as a sustainable water resource.

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