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Contribution of Geophysical Data for The Prevention of Geotechnical Risks Related to Building Cracking in Agadez Region (North Niger)

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Abstract: *The seismic and magnetic data are well known for the investigation of tectonic structures and their directions on surface and subsurface, a methodological approach integrated the seismic and magnetic data interpretation combined with field measurement on cracked building and its underlying substratum, represented by Agadez sandstones and basement. The extraction of seismic lineaments from West African seismic map showed the seismic directions oriented NW-SE (N135 to N160°), passing through the studied area. The structural interpretation of magnetic map show that the Agadez region is also affected by the subsurface lineaments mainly oriented in NW-SE (N135°) directions, which are similar to the identified seismic lineaments in the same zone. A structural study carried out on the Agadez sandstones and the underlying basement, showed that faults and fractures oriented N120° to N165°, affect both the basement of the Aïr Mountains and the sandstone formations on which the city of Agadez is built. These observations showed that building cracking in Agadez region has a higher propagation tendency according to the directions ranging from NW-SE (N135°) to NNW-SSE (N165°). Therefore, the buildings cracking has a stronger propagation component according to these mean directions those are not recommended for building. To prevent and reduce the risks related to building cracking in Agadez region, it is highly recommended to build in the minor directions of cracking propagation which correspond to NE and SW directions.*

Keywords: *Seismic, magnetic, prevention, building cracking, Agadez.*

1. INTRODUCTION

This study tries to highlight the role of magnetic and seismic data in the prevention of building cracking which constitute a geotechnical risks in Agadez city. This city is built on the faulted and fractured sandstones formation of the “Agadez Sandstones”, which deposit in unconformity on the basement of the Aïr Mountain [1].

According to the previous geological data [2, 3 and 4], all these geological units (basement and basin) are affected by brittle deformations in the state faults and or fractures with several orientations. Thus the main directions of faults were made into evidence at regional scale in Agadez region are (Figures 1):

- the In-Azaoua-Arlit fault system, N0° trending and the Madaouéla N30° fault system (Figure 1),
- the N130° to N140° trending faults system, affecting the Aïr Mountains, is less frequent in the Tim Mersoï basin,
- the N70°-N80° fault system (farther to the west in the DASA area) has been reactivated in dextral sense during the Upper Cretaceous as indicated by the results of structural study obtained in the Tim Mersoi basin [2,3 and 4].

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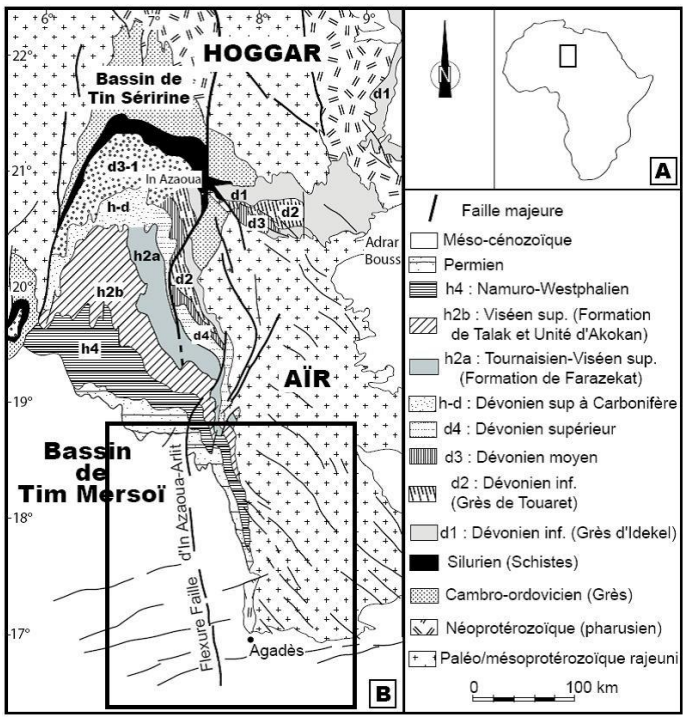


Figures 1: Location of survey area within the geological map of the Eastern part of Tim Mersoï Basin, from the previous geological data [2, 3, and 4].

2. MATERIAL AND METHODS

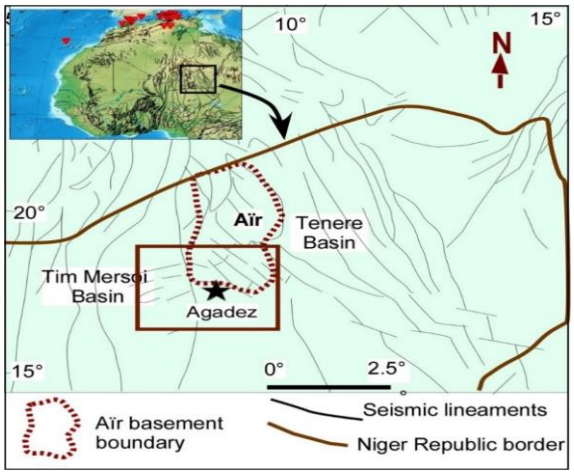
The methodological approach is based on the review literature, field investigation and processing and statistical analysis of field collected data: i) the review literature focused on bibliographic research of thesis, scientific articles, scientific reports and all other document relative to the geology of the studied zone, ii**)** the interpretation of geophysical data consists of lineaments extraction from aeromagnetic and seismic maps and iii) the field investigation consisted of prior identification of the most affected sectors by cracking and in situ structural measurement of cracks planes. This stage was carried out with material as following: GPS (for site location), Compass (for direction and dip acquisition of a structure). The obtained data were processed by using the ArCGis 10.1 and Drowing Software Canvas 11.

3. RESULTS AND DISCUSSION

Seismic data

Structural analysis of seismic cartographic data [5] highlighted two regional lineament systems: the NNW-SSE seismic lineament affecting both the Aïr basement and Tenere basin in East and N-S fault system extended in the Tim Mersoi basin in West (Figure 2). In addition, some localized seismic lineaments oriented NEE-SWW and cutting the regional lineaments were identified in the western region of Agadez. This regional lineaments

would control the setup of the uranium mineralization in Arlit region [6], and in Tenere basin it constitutes a NNW-SSE petroleum system of Termit basin [7].



Fgure 2: Seismic lineaments of Niger Republic and Agadez region extracted in the case of this study from seismic map West Africa [5], showing the NNW-SSE and N-S fault system affecting the survey area.

Magnetic data

Lineaments extraction (in the case of this study) from aeromagnetic cartographic data [8] of Agadez region at 1/200 000ème (Figure 3) showed two types of magnetic lineaments according to their size: minor and major one. The major part of these magnetic lineaments are oriented in NW-SE direction (manly N135° to N140°). In addition, a major magnetic lineament oriented N-S corresponding to In-Azaoua-Arlit fault system revealed by previous geological works was identified (Figure. 1). These similar directions were previously identified by seismic cartographic data (Figure 2). These observations reveal that the subsurface seismicity directions of Agadez region is mainly NW-SE trending those cannot be recommended or avoided for the construction of big buildings.

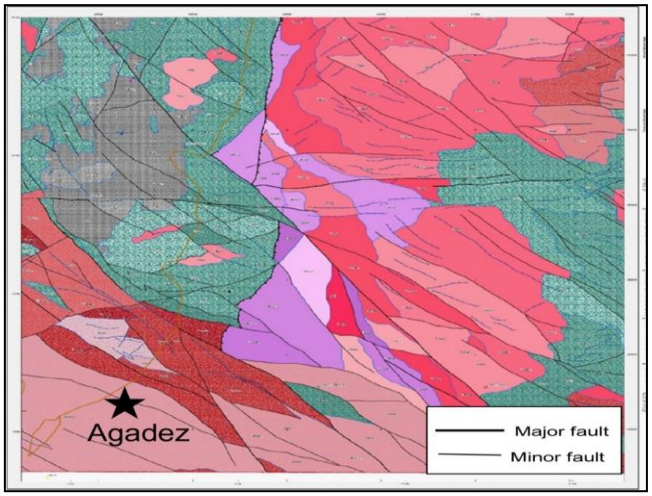


Figure 3: Lineaments extraction from aeromagnetic cartographic data [8], showing the NW-SE major directions of magnetic lineaments affecting the Agadez region.

Field data

The field investigations and measurements of cracks planes was carried out on sandstones formations and on buildings (Figure 4). The obtained microtectonic data are presented in the tables 1 and 2. The structural analysis of obtained data showed that the cracking event affects both the sandstone formations and buildings (Figure. 4).

To determine the major direction of the propagation, the 220 measured planes were statistically analyzed by direction interval of 45° from the North (Table 2 and Figure 5). The obtained results of statistical analysis by the percentage of directions show that:

- North to Northeast (N0°-N45°) directions: 25%,
- Northeast to East (N45°-N90°) directions: 30%,
- East to Southeast (N90°-N135°) directions: 12.73% and
- Southeast to South (N135°-N180°) directions: 32%.

According to these observations, the directions ranging from NW-SE (N135°) to N-S (N180°) are the majority with 32%, followed by NE-SW (N45°) to E-W (N90°) directions with 30%. Therefore, the buildings cracking has a stronger propagation component according to the mean directions NW-SE (N135°).

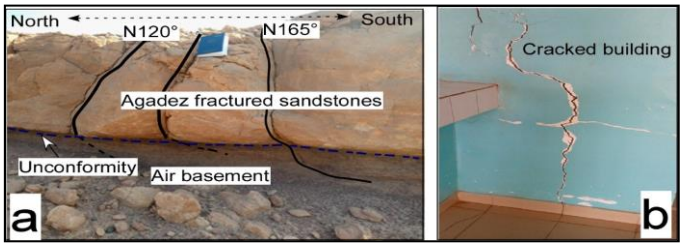


Figure 4: in situ photography showng (**a**) Agadez fractured sandstones with its underlying basement of Aīr and (**d**) state of cracked building in Agadez city.

Table 1. Some of measured cracks from building and Agadez sandstones

Direction	Dip values	Dip sector
N120°	85°	SW
N150°	75	NE
N80°	90	V
N150°	90	V
N90°	80	S
N50°	70	SE
N70°	90	V
N135°	80	SW
N140°	85	SW
N35°	90	V
N85°	90	V
N160°	90	V
N180°	70	E
N40°	70	SE
N85°	90	V
N100°	50	SSW

***Note: S**: South, **N**: North, **W**: West, **E**: East, **V**: Vertical.*

Table 2. Statistic of measured cracks according to their directions.

Direction intervals	Effective	Percentage (%)
[N0°-N45°]	55	25,00
[N45°-N90°]	66	30,00
[N90°-N135°]	28	12,73
[N135°-N180°]	71	32,27
Total	220	100,00

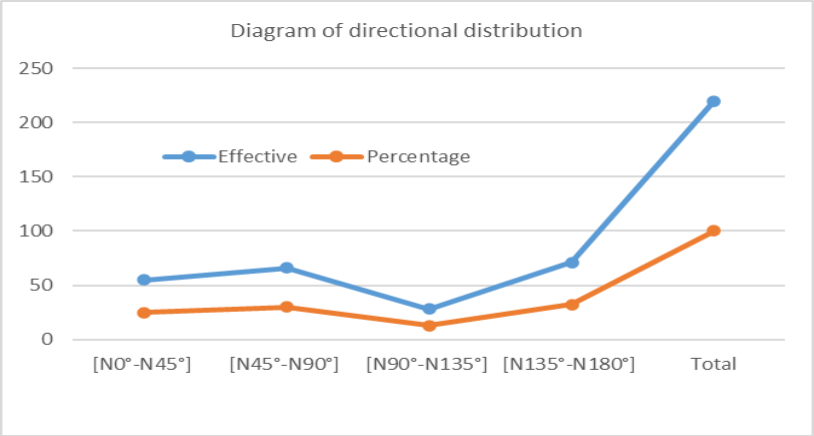


Figure 5: Diagram of directional distribution of all measured cracks on Agadez sandstones and on building.

Discussion on tectonic origin

Analysis of seismic and magnetic cartographic data showed two main directions: N-S and NWW-SSE directions. According to the previous geological works, the N-S regional lineament systems corresponding to the In-Azaoua-Arlit fault system extended in the Tim Mersoi basin in West and Raghane fault system affecting similarly the Precambrian Air basement and Tenere basin in East. The NNW-SSE lineaments represent the relay of N-S regional fault systems and causing the building cracking in Agadez region **[**1**]**. These two fault systems were the focus of three seismic events (4th July 1969, in 19th May 1967 and 18th January 2017 **[**5**]**). According to geological data obtained in Hoggar [9, 10, 11], these regional fault systems derive from the reactivation of three major sub-meridian shear zones in Hoggar: East Ouzzal shear zone (3°30'), Tekouyat shear zone (4°50') and Raghane shear zone (8°30').

4. CONCLUSION

This study focused on the role of seismic and magnetic data for the prevention of geotechnical risk related to buildings cracking. A Combined analysis of seismic, magnetic combined and field data led to determine the major directions of cracks propagation. Indeed, according to the obtained results, the major direction of cracks propagation corresponds to the

NW-SE to N-S seismic and magnetic lineaments. Feld verification has showed that these lineaments correspond to a cracks and fractures system oriented in the same directions (NW-SE to N-S), affecting both sandstones formations and building in the Agadez city. Therefore, these directions are not recommended for the building construction regarding its high level of cracking. Thus, opposites directions corresponding to NE-SW (N45°) to E-W (N90°) are highly recommended for building construction in this region.

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