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RESEARCH ARTICLE

3D GEOLOGICAL MODELING OF THE UNDERGROUND USING GDM MULTILAYERS 2014 SOFTWARE APPLICATION TO THE CITY OF CASABLANCA IN MOROCCO.

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Abstract

The creation of 3D geological models is essential in urban planning. These allow developers and builders to have a preliminary and quick idea on the site. Also, they save time and redundant appeal to geotechnical laboratories. The work concerns the city of Casablanca in Morocco. Its goal is to create a 3D geological model of the underground of the study area, using the GDM Multilayers 2014 software.

For this purpose, a series of 58 surveys of the region were collected and used. This data has been inserted into the GDM software which allowed the generation of the drawing of logs of all the surveys, as well as the creation of the synthetic log of the zone. The latter has shown that the dominant stratigraphic formations in the area are: clays, limestones, sandstones, sands and shales. Using the interpolation techniques available on the software, 2D Grid models of each formation of the synthetic log have been generated. This allowed the creation of the 3D structure of the geological model, as well as the generation of 2D geological section at any point of the zone.

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Introduction:-

Today, many of the problems that affect urban developments are related, directly or indirectly, to the geological and geotechnical conditions that pre-exist on the site. (McCall et al. 1996). Having an image, even approximate, of the geometric properties (thickness, extent) and geotechnical superficial formations allows, in the draft phase to better design campaigns recognition and reduce surprises (BRS 2017). Consequently the idea comes to design geological and geotechnical databases and 3D models. These allow the developer, in the pre-construction phase, the knowledge of the site data. In fact, the idea is not new, since the advent of computer science, geologists and geotechnicians have tried to design and implement programs for the storage and processing of geological and geotechnical data (Kaâniche et al. 2000). Newly innovated, 3D Geological Modeling, is an effective tool to save redundant recourse costs to geotechnicians, as it represents an instrument against the loss of considerable time. In Morocco, rare organisms have a 3D geological model of their areas. Yet recently OCP has introduced this technique in order to quantify the phosphate deposits. On the other hand, the territorial administrations, which are normally supposed to be the first ones interested in the introduction of the GIS cells necessary for the geological and geotechnical modeling in 3D, have not yet made the step, or at best, did so very shyly.

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It is within the framework of this problematic that this article is integrated with the objective of producing a 3D geological model of the study region integrating various geotechnical and geological parameters, which can be used as a management decision support tool.

Study area

The study area is located in the southeastern part of the Casablanca prefecture, which belongs to the central part of the wilaya of Greater Casablanca (Figure 1). The latter is located on the Atlantic coast in northwestern of Morocco around the latitude of $33^{\circ} 35'$ north and the longitude of $7^{\circ} 25'$ west.

Casablanca is characterized by an average temperatures of 12.4°C in winter and 22.9°C in summer with a temperate and humid climate. Average annual precipitation is between 300 and 500 mm (L. Ikram et al., 2014). According to the last census of 2014, the population of Casablanca has exceeded four million inhabitants (RRC 2014).

The total area of the study area is 33 km^2 and it consists of Ben msick prefecture, Fida Mers sultan prefecture, Sidi Moumen district, MoulayRachid district prefecture and Mediouna province (Figure 1).

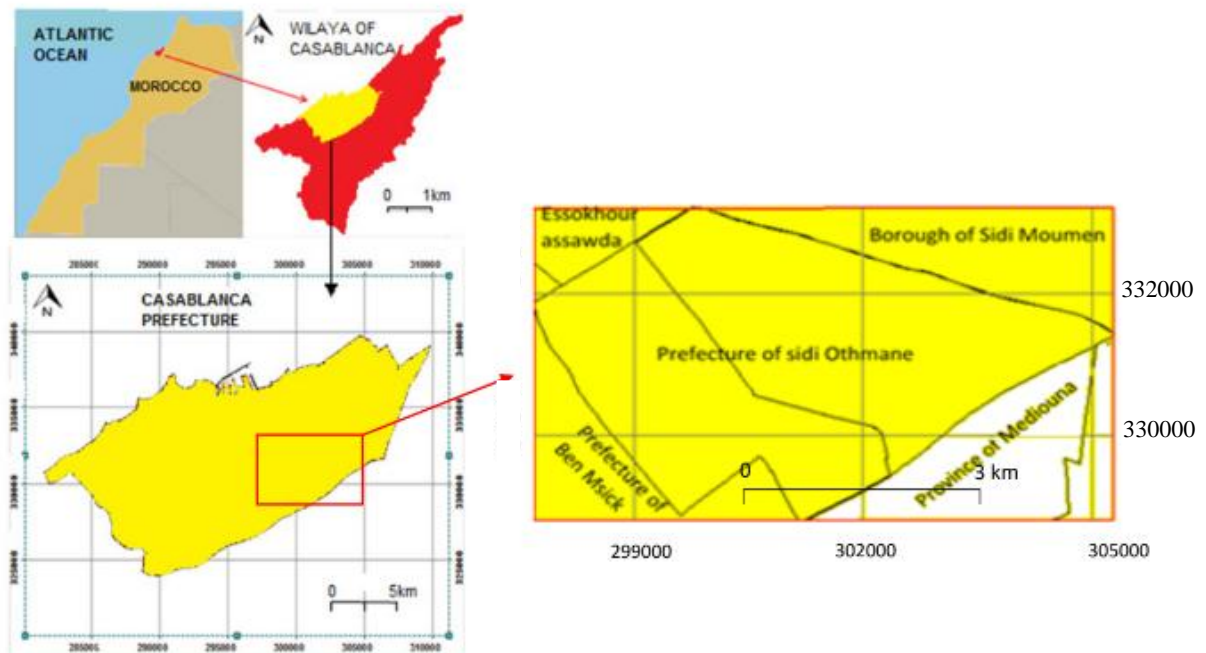


Figure 1:-Study area.

Data and material

Used material

In this article the original version of the GDM MULTILAYERS 2014 software has been used, in the form of a key delivered by the BRGM laboratory. Developed by the latter, the GDM 2014 software allows the management, representation and modeling of geology data. GDM 2014 produces 3D views, cross-sections, maps and survey logs and also allows a high valuation of data through the construction of geological models, the interpolation of various parameters (grades, piezometric dimension, geotechnical parameter, ...) and quantification of volumes. GDM Multilayers 2014 is an extension of BRGM's GDM Standard Edition software that enables the automated construction of multilayer geological models (BRGM 2017).

Collection of data

A series of 58 geotechnical surveys have been collected and used in this article. Most of the polls have been geo-located. Those not geo-referenced were projected from ground plan that indicate their locations. Those without a mass plan or who are poorly or not well located were not selected for this study

Structuring the database of polls

For the realization of the synthetic logs of the surveys, it was first necessary to prepare the available data in the appropriate format adapted to the GDM software, which is the Excel format. It is a table in which each sounding is represented by its data: Sounding number, Coordinates X, Y and Z, Depth beginning (m), Depth end (m), Lithology, Litho code, Age, Code Age.

Categories encountered are 47 in number. In order to facilitate the work, these have been grouped into 10 codes, and this according to the geological and geotechnical characteristics bringing them closer; (see table below).

Lithological codes	Geological categories
litho00	Embankments
litho01	Clays
litho02 (non-consolidated Formations)	Sandy tuff
litho03	Sandstone
litho04	Sands
litho05	Calcareous crust
litho06	Fractured shales
Litho07	Gritty clays
Litho08	Clay silt
Litho09 (Consolidated Formations)	Consolidated limestone tuffs
TV	Topsoil

Table 1 :-The lithological codes of the different geological categories.

According to these surveys, it is essentially the following five formations that are mainly encountered: clays, limestones, sandstones, sands and shales.

Creation of the synthetic log of the study area using the GDM Multilayers software

The generation of the synthetic log of the studied area requires, first of all, the correlation between the different logs of the surveys, this makes it possible to identify the dominant stratigraphic formations in the zone, as it requires a topographical analysis of the zone. The synthetic log database was prepared under GDM Multilayers 2014, and generated the following cut:

Geological formations	Thickness of the layer
Topsoil	20-70 cm
Vernal calcareous crust	10-40 cm
Clay	10 cm-1,00 m
Tuff	0 – 2,00 m
Sandstone	0 – 4,00 m
shales	0-2,00 m

Table2: Thicknesses of different lithological formations.

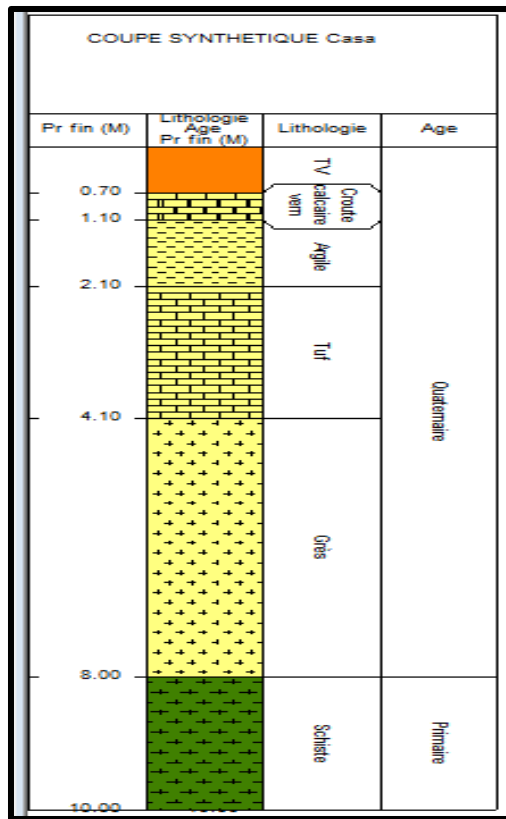


Figure 2:-Synthetic log of the study area.

Generation of 3D model

6.1. Generation of the 3D structur

Before starting modeling under GDM Multilayers, it was first necessary to prepare the Excel databases corresponding to each code of the synthetic log of the zone. In other words, it is necessary to first identify the codes in question in the different polls, and determine their characteristics (the coordinates X, Y and Z; The height of the roof of the formation modeled by the Z-Roof parameter and the height of the wall of the formation modeled by Z-wall, in addition to the thickness of the formation). After preparing the databases that correspond to the different synthetic codes, they are inserted under GDM, and interpolated by code. After interpolation we obtain the 2D Grid of each code.

To make the 3D model, a basic Grid must be chosen on which the others will be superimposed. In this work, the topographic Grid layer has been selected as a base layer. In this way the six elevations of the walls of the layers are superimposed namely: ZMTV, ZMCL, ZMAG, ZMTF, ZMGR, ZMSC.

For the generation of the 3D model the following colors have been chosen for different codes. Namely ZMTV for the TV code, ZMCL for the calcareous crust code, ZMAG for the clay code, ZMTF for the tuff code, ZMGR for the Sandstone code and ZMSC for the Schist code.

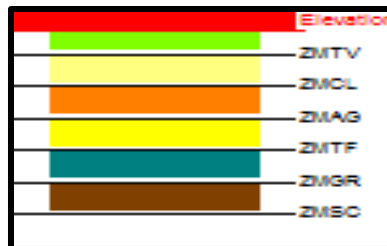
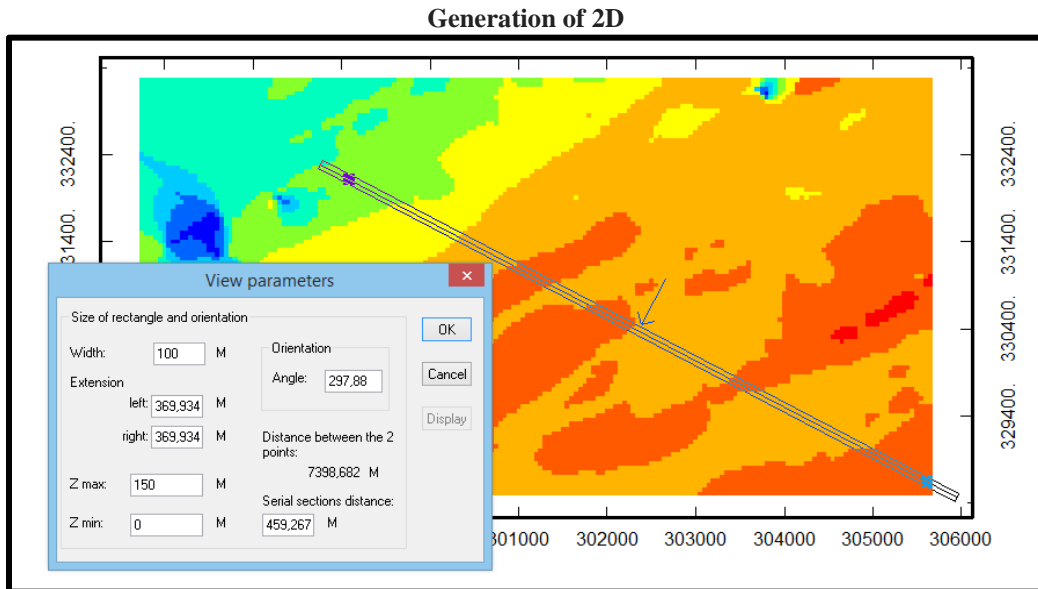


Figure 1:-Legend of the layers of the geological 3D model



slices on the 3D model

Figure 2:-Location of the AA 'section on the Topographic Grid The arrow point indicates the direction of observation of the section.

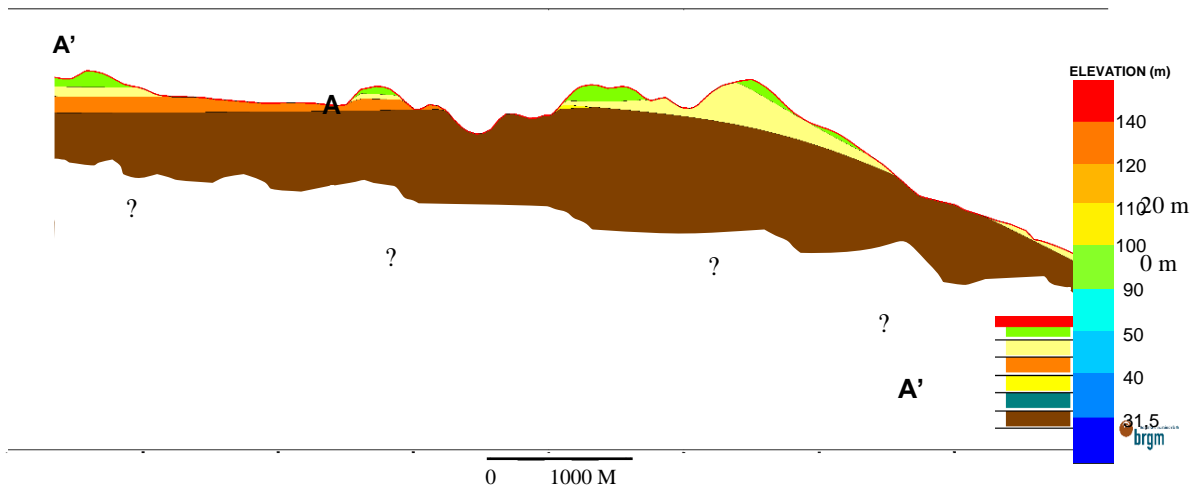


Figure 3:-Section AA'

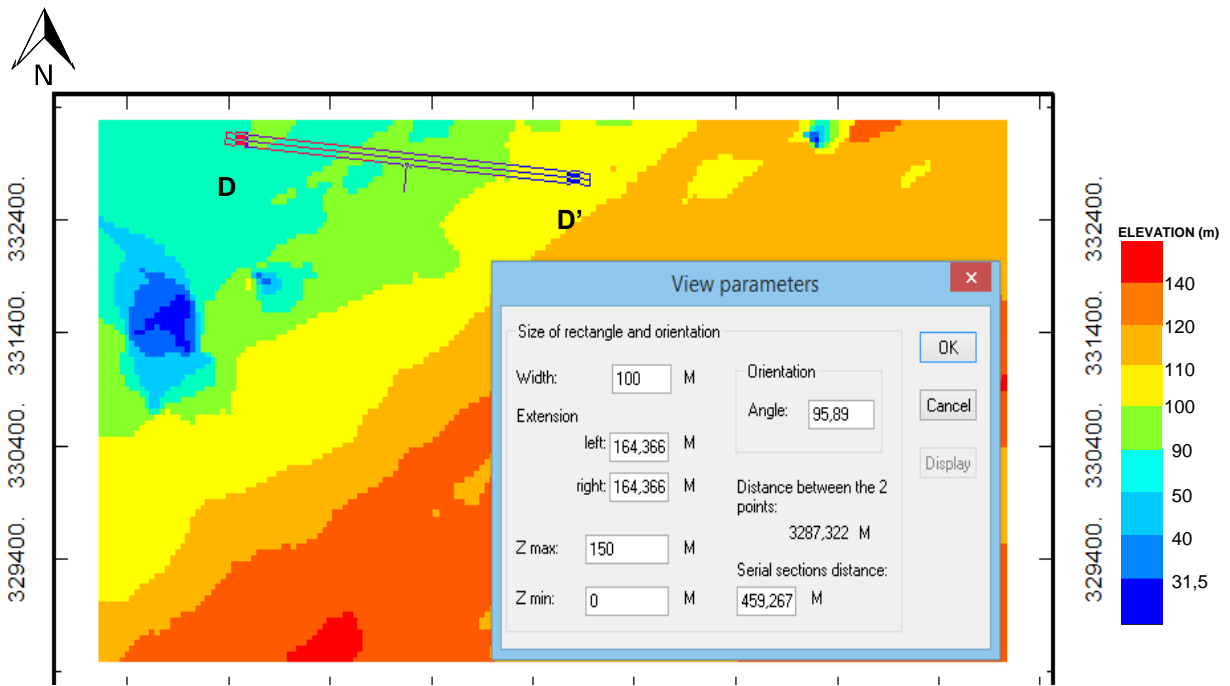


Figure 4:-Localization of the DD 'section on the topographic Grid

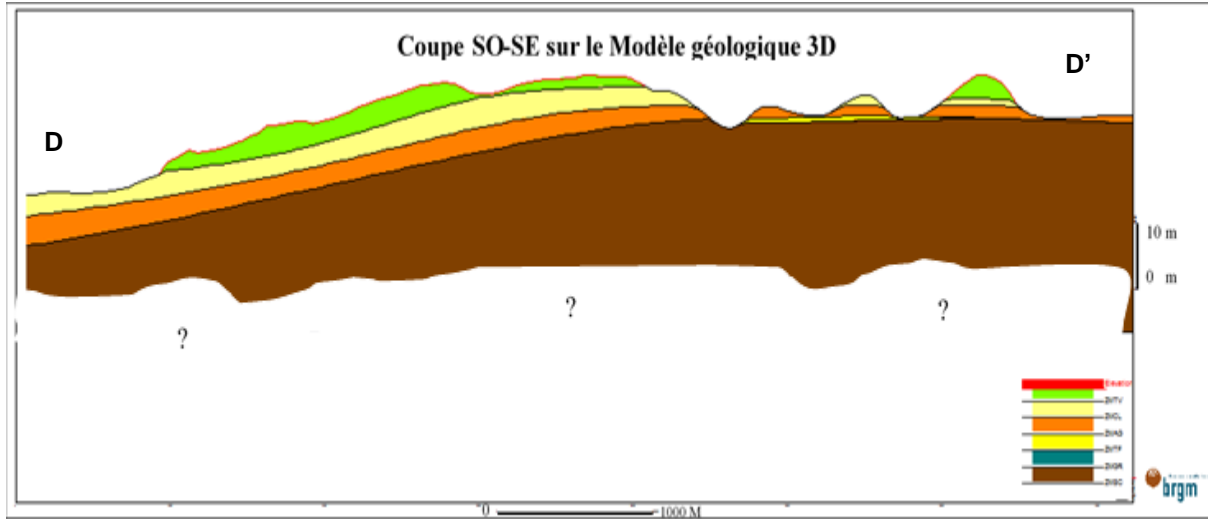


Figure 5:-3D model of geological formations

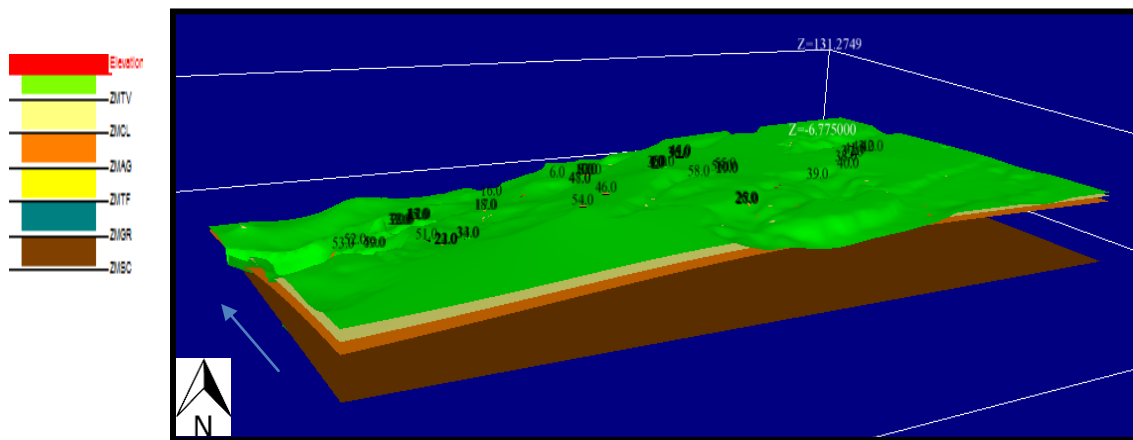
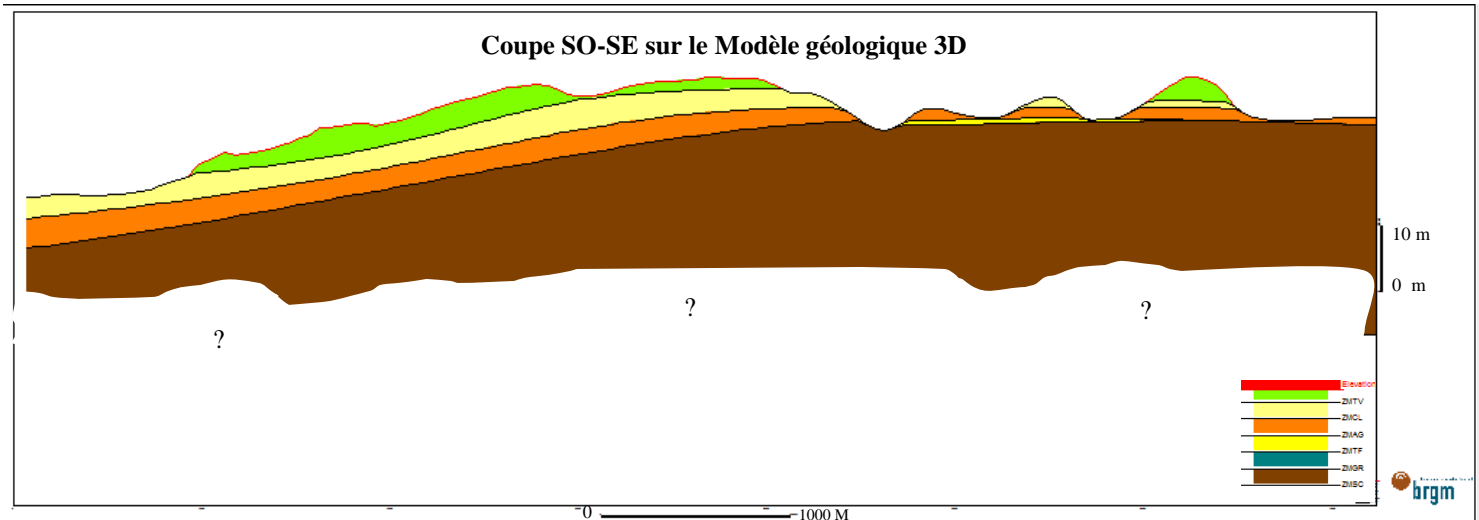


Figure 6:-Location of surveys on the 3D model

Conclusion:-

This work deals with the 3D geological modeling of the near subsoil of the South-East zone of Casablanca, using the software GDM Multilayers 2014. This study first made it possible to create a geological database of the subsoil by generating the stratigraphic logs of all existing surveys in the study area. In addition, it generated the synthetic section of the area in question, consisting essentially of five sedimentary formations namely: vernacular limestone, clay, tuff, sandstone and shale. On the other hand, this work led to the creation of the topographic Grid of the zone as well as all the Grid 2D of the different layers, which helped to generate a 3D geological model. The 3D structure presented in this work, helps users to make 2D cuts in any point of the zone studied, in order to know the topography of the ground and to visualize the different geological layers. Moreover it gives a reliable information that the developer can use if necessary. As a result, it will help to better manage urban development, enhance the value of data that represents an important Moroccan heritage and to optimize the financial expenditures of the public and private sectors; avoiding geological and geotechnical studies, which are generally expensive. Finally, it helps to avoid any potential risk due to geological and geotechnical conditions. These databases can and must be fed continuously. This work which is done on the Casablanca area must be generalized throughout the Kingdom of Morocco in order to provide administrations with their own databases.

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