

# **Inventory and Monitoring the Evolution of the Quarrying Exploitation in the Region Tangiers-Tetouan (Morocco) in Order to Design a GIS tool for the Management of Useful Geomaterials**

**(Case Study: Aggregate Quarries in the Haouz mountains)**

**El Maftouhi TARIK, DELLERO Hatim and El Kharim YOUNESS**

**Key words:** e-Governance, Geoinformation, Geomaterials, quarrying, Tangiers-Tétouan

## **ABSTRACT:**

The northern region of Morocco has experienced in the last decade an increased economic growth and made much progress developing its infrastructure, public works, urban and industrial areas. This development has led to an increased demand for Geomaterials, which has caused uncontrolled mining exploitation caused by the lack of regulation and deficiency in legislation. Using a Geographic Information Systems (GIS) with its extensive capabilities to dealing with spatial problems and multilayering, would be necessary to provide a diagnosis and an overview to the current situation.

This study presents, on one hand, a general view of the mining activity in the mountains of Haouz, as a case study, based on multisource data gathered from the geological and topographical maps, the result of a national inventory of quarries published in 2012, reports of impact study of the different quarries, etc... On the other hand it follows the rapid spatial evolution in the study area, based on the use of Google Earth Images.

The main goal of this study in the long term is to create a multi-layered geographic Database that includes the different information related to quarrying and extend it the cover the whole region of Tangier-Tetouan, and provide closer look to the current situation that can help decision makers in finding solutions for its problems and the overall management of quarrying and finding optimal choice of sites by :

- Using an interactive localization of useful materials in the region Tangiers- Tetouan.
- Consideration of all parameters that will be all integrated in the GIS application.

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## **INTRODUCTION**

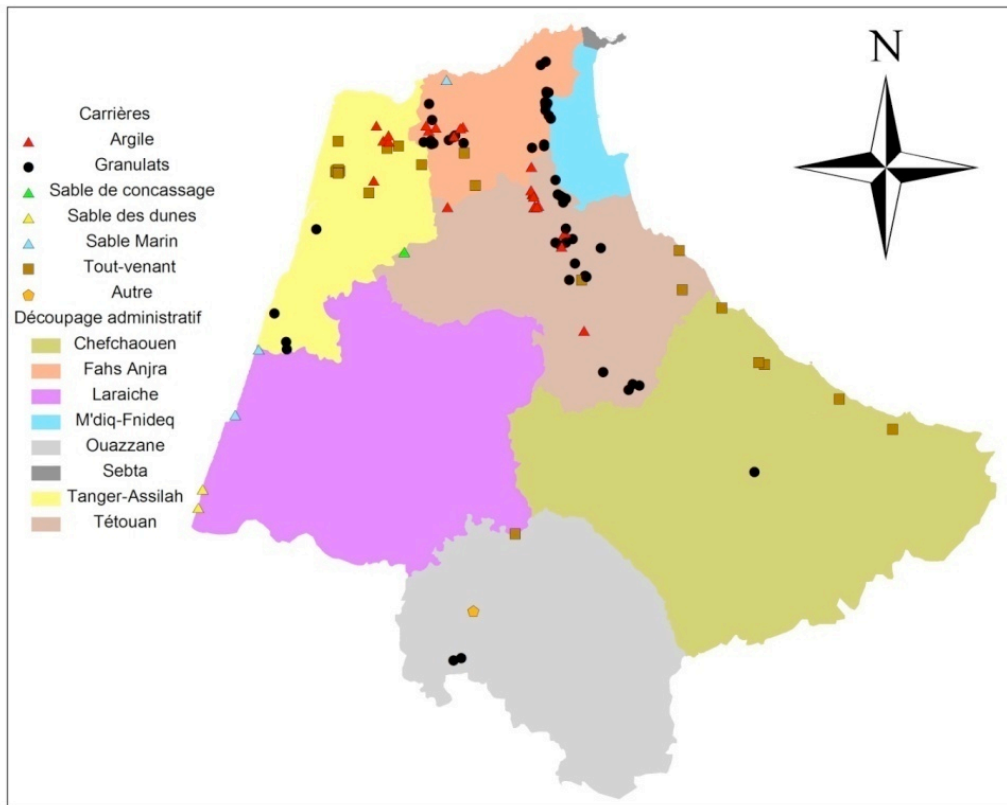
A geographic information system (GIS) allows researchers to investigate spatial patterns within their earth surface data and understand the relationships that exist between the physical environment and human activities. The proper integration of GIS and its associated technologies such as remote sensing, have opened up new frontiers often termed 'geospatial' which has so far proved helpful in solving geographic problems and identifying potential locations.

Geomaterials are very integrated in our life and constitute the basis of the whole civilization; it is the main engine, not only in the economic world, but also in social development.

### **1. AN OVERVIEW OF THE SITUATION OF SUPERFICIAL MINING IN THE TANGIERS-TETOUAN REGION :**

The region of Tangier-Tetouan is experiencing an intense extractive activity of geo-materials in construction. In an area of 11570 km<sup>2</sup>, equivalent to 1.62% of the Moroccan territory, this region contains 112 quarries equivalent to 6% of the total number of quarries in Morocco (fig.1, tab.1).

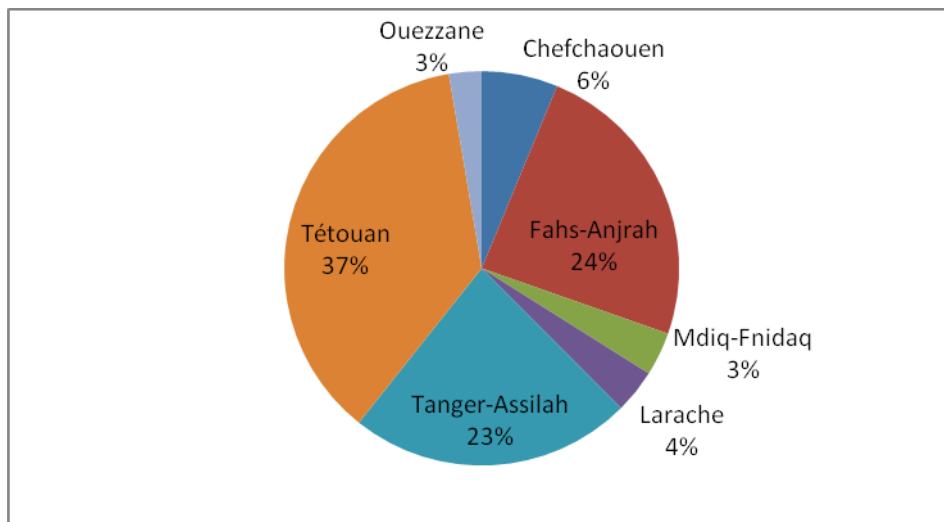
Distribution of the mining activity within the region itself is uneven, with 84% of quarries located in the provinces of Tetuan, Fahs-Anjarah and Tanger-Assilah (fig.2) due to their proximity to the mining area of materials and the high demand in these provinces (port infrastructure, road and rail, social housing programs ...).



**Fig. 1 :** Spatial distribution of quarries in the region of Tanger-Tétouan

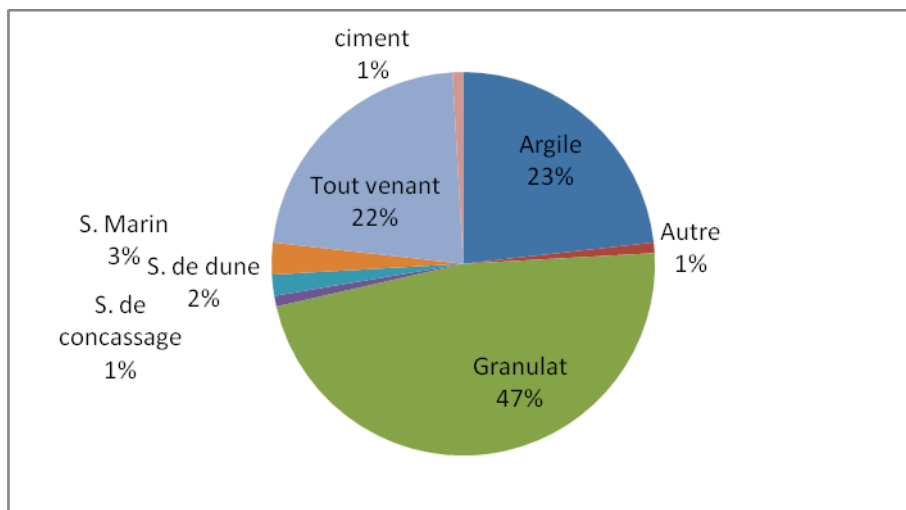
**Tab. 1 :** regional distribution of quarrying in morocco (study of Minister of transport and equipment, October 2012)

| Région                          | Number of quarry |
|---------------------------------|------------------|
| Meknés-Tafilalet                | 285              |
| Chaouia – Ouardigha             | 239              |
| Souss- Massa-Draa               | 180              |
| Marrakech- Tensift- Al Haouz    | 154              |
| Doukkala-Abda                   | 147              |
| Taza-Alhoceïma-Taounate         | 132              |
| Oriental                        | 119              |
| Rabat- Sale-Zemmour-Zaer        | 117              |
| Tanger-Tetouan                  | 112              |
| Tadla – Azilal                  | 89               |
| Fès-Boulemane                   | 84               |
| Grand Casablanca                | 58               |
| Guelmim - Smara                 | 53               |
| Laayoune-Boujdour-Sakia Elhamra | 53               |
| Gharb-Cherarda-Beni Hsan        | 49               |
| Oued Eddahab-Lagouira           | 14               |
| <b>Total</b>                    | <b>1 885</b>     |



**Fig. 2:** Distribution of the number of careers by province of the region Tanger-Tétouan

The materials extracted in the region vary between materials derived from crushing of massive rocks, clays, alluvial Sand, dune sands or marine sand. The exploitations in the region Tanger-Tétouan are intended exclusively for the production of the construction materials (aggregate, cement, precast concrete, concrete, bricks, ceramics,... etc) and 74% of these mining activities operate on massive rocks, of which the majority are dedicated to the production of aggregate (fig4.).



**Fig. 4 :** Nature of materials extracted by number of quarries in the region Tanger-Tétouan

## 2. AGGREGATE QUARRIES IN THE REGION: TANGER-TÉTOUAN

Quarries of massive rocks in the region (aggregates, cement and ungraded) constitute the majority of the farms in the region with 79 career occupants a 1402 hectares and producing about 8 million cubic meter of materials per year. 53 of these quarries are destined for the production of aggregates, occupying an area of 8.3 Km<sup>2</sup> with an annual output of 3.7 million cubic meters per year. These Quarries are distributed over 15 municipalities in 6 different provinces, and display very different values in terms of the number of quarries per municipality, the area and the annual production reported by operators between these municipalities (Tab.2)

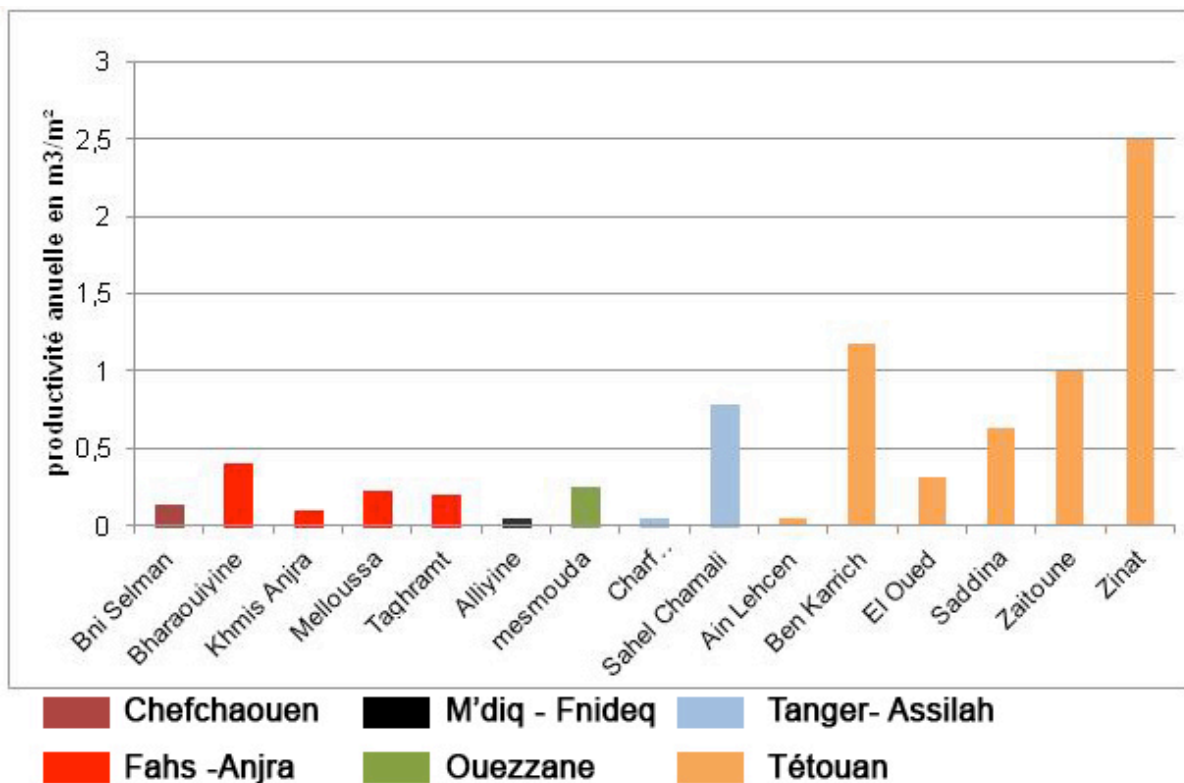
**Tab. 1 : Areas and annual production of the quarries of aggregates of crushing by town in the region Tanger - Tétouan**

| Province       | Commune       | number | Area (m <sup>2</sup> ) | Production (m <sup>3</sup> /an) | Rate of annual production by area (m/an) |
|----------------|---------------|--------|------------------------|---------------------------------|--|
| Chefchaouen    | Bni Selman    | 1      | 115000                 | 16000                           | 0,13913                                  |
| Fahs anjra     | Bharaouiyyine | 3      | 113008                 | 45650                           | 0,403954                                 |
|                | Khmis Anjra   | 3      | 406120                 | 40000                           | 0,098493                                 |
|                | Melloussa     | 6      | 206758                 | 46000                           | 0,222482                                 |
|                | Taghramt      | 8      | 3332112                | 650000                          | 0,195071                                 |
| M'Diq-Fnideq   | Alliyine      | 4      | 250000                 | 36 000                          | 0,052197                                 |
| Ouezzane       | Mesmouda      | 2      | 162979                 | 40000                           | 0,24543                                  |
| Tanger-Assilah | Charf Mghogha | 1      | 20000                  | 1000                            | 0,05                                     |
|                | Sahel Chamali | 3      | 475819                 | 372000                          | 0,78181                                  |
| Tétouan        | Ain Lehcen    | 1      | 25000                  | 1000                            | 0,04                                     |
|                | Ben Karrich   | 5      | 655948                 | 774500                          | 1,180734                                 |
|                | El Oued       | 5      | 406674                 | 128640                          | 0,316322                                 |
|                | Saddina       | 6      | 1341922                | 848000                          | 0,631929                                 |
|                | Zaitoune      | 1      | 50000                  | 50000                           | 1  |
|                | Zinat         | 4      | 272132                 | 680000                          | 2,498787                                 |
| <b>total</b>   |               | 53     | 8273168                | 3728790                         | 0,450709                                 |

In order to compare the annual production by area of aggregate quarries in each municipality, we estimated an index (I) in these careers:

$$I (m/an) = \frac{\text{annuelle production (m}^3/\text{an)}}{\text{area (m}^2\text{)}}$$

The results show that the annual production per area index varies from one municipality to another with high values reported in the municipalities of Zinat, Aken and Ben Karrich South of Tetouan. In the other hand, the municipalities located in the Haouz present an annual production by area (I) very low, including the municipalities of Tlata de Taghramt and El Alleyine, where the mining areas are considerably larger compared to the rest of the plots(fig.6).



**Fig. 6 the index values of the annual production by area of the quarries of aggregate by communes in the region Tanger-Tétouan**

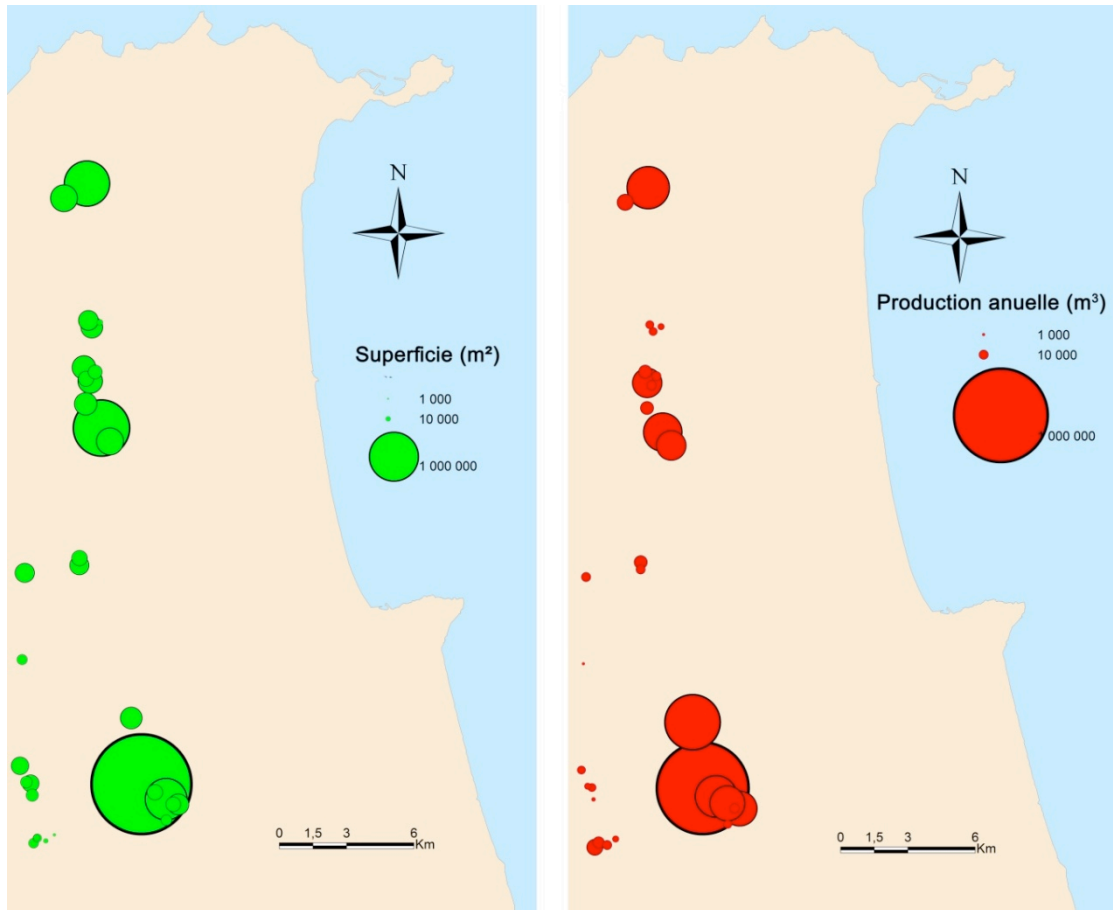
### 3- CASE STUDY: THE HOUZ MOUNTAINS

The study covers the sector of the Haouz, a mountainous area that constitute the north western extremity of the Rif mountain range in northern Morocco. Located between the city of Tetouan and the Strait of Gibraltar, it currently contains 21 active quarries, 20 of which produce aggregates, the other one provides limestone for the production of cement. These

quarries are not equally distributed between the different communes; the majority lies in the rural communes of Saddina and Tlata Taghramt (fig. 7).

From 21 careers that exploit the formations of the Haouz, 20 quarries are devoted to the production of aggregates. They occupy an area of 557363 m<sup>2</sup> that is 67.3% of the total area of aggregate quarries in the region and produce 1224000 m<sup>3</sup>/year or 32.8% of the regional production. The index of the annual production by area for these is equal to 0.22 m<sup>3</sup>/year for a regional value of 0.45%. Indicating that, although the aggregates quarries in the Houz Sector cover a much larger area, the production in these quarries remains low compared to the regional average.

The lack of correlation between the area and the annual production of aggregate quarries can be also noticed within the Haouz sector itself, as shown in the figure 7, where the size of the green circles are proportional to quarry's areas and the red circles to the values of the annual productions.

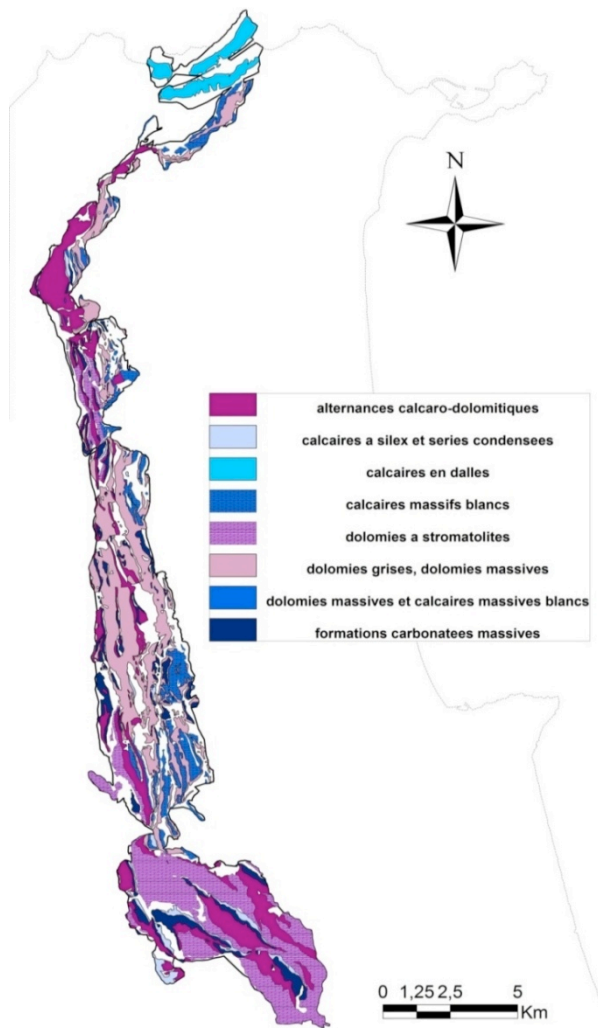


**Fig. 7 : Graphic representation area in m<sup>2</sup> (left) and the annual production in m<sup>3</sup>/year (right) in the study area Report of these charts on a background of the provinces**

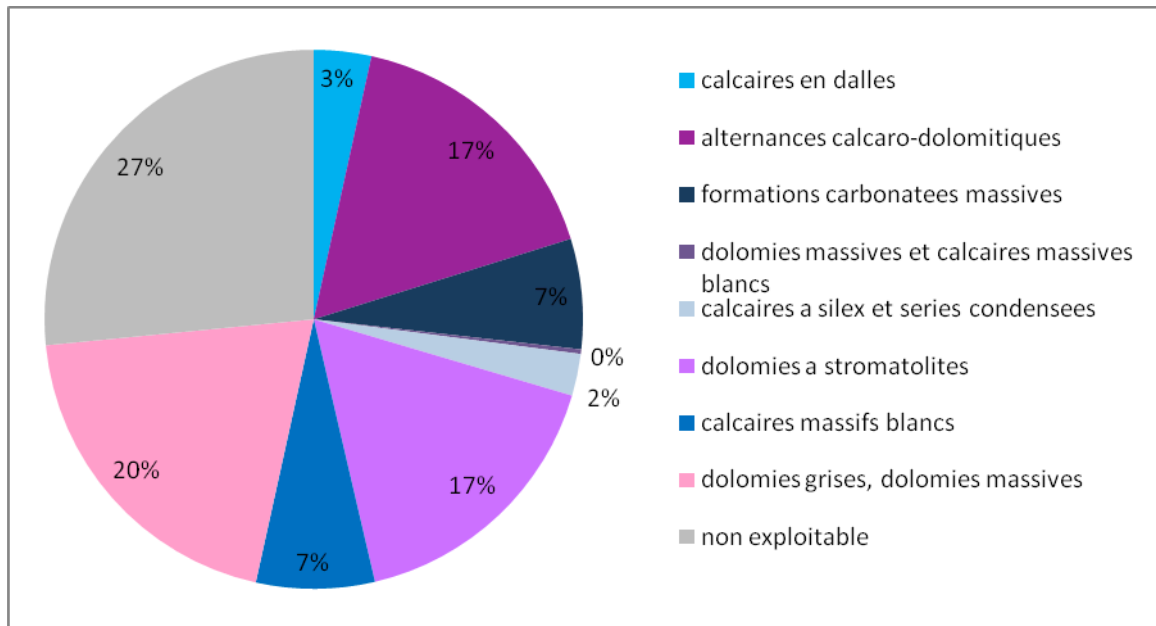
### **3.1. The geological characterization of the quarries activity:**

The Haouz mountains form a rich deposit for the exploitation of the massive rocks due to their abundance of calcareo-dolomitic formations that covers 73%, in surface, of its area, with dominance of dolomitic facies which occupy 37% between massive Dolomites, then calcareo-dolomitic alternations which cover 17% of the the deposit's surface. (Fig.8,9)





**Fig. 8 Map of the exploitable trainings for the production of aggregates in the area of the Haouz.**

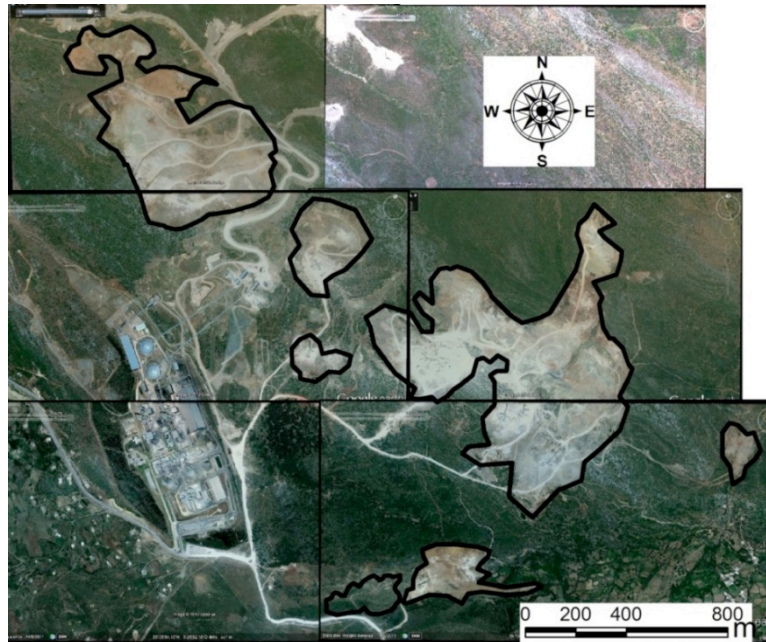


**Fig. 9 : Geological composition of Haouz**

### **3.2. Spatial evolutions of quarries in the study area:**

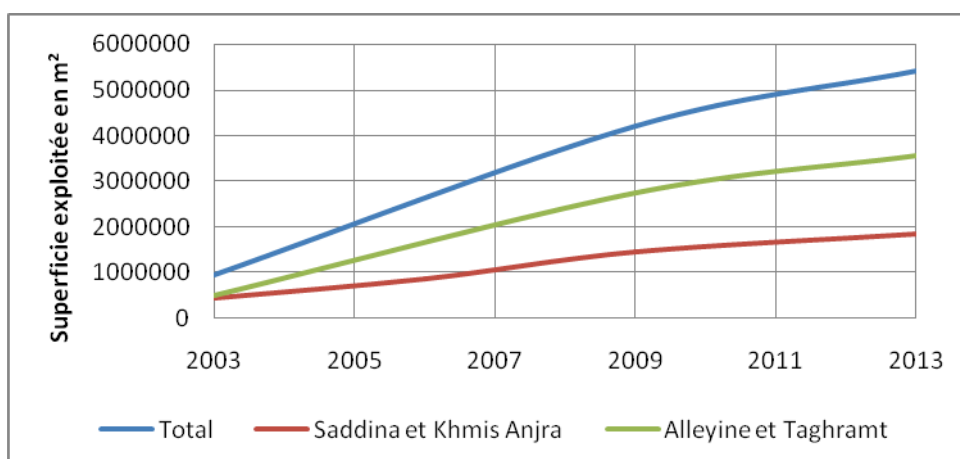
The first traces of mining in the Haouz Mountains have started in the 1990s with small to medium scale quarries. But since the beginning of the 2000's, and with the rapid socio-economic development in the region, several new quarries have been settling in the massif of the Haouz.

The photo-interpretation of several updates of Google earth images between 2003 and 2012 allowed the monitoring of this spatial evolution of the limits of these quarries. By georeferencing those images using a GIS software over a topographique base map 1:25000 (fig.11)



**Fig. 11 : data acquisition using Google Earth images**

The analysis has shown that the mining area in the Haouz mountains grew more than five times with 947800 m<sup>2</sup> of land occupied in 2003 compared with 5408400 m<sup>2</sup> in 2013, or 0.96% to 5.5% of its surface, respectively. The maximum extension of occupation took place in the period between 2003-2009, coinciding with the economic recovery experienced during this period (the construction Tangier-Med port and associated infrastructure; highways, railway, real estate projects,...). This spatial extension of mining is noted more significantly the communes Tlata Taghramt - El Alleyine, where the extraction area have multiplied almost 7 times between 2003 and 2012, due to its close proximity to the delivery market in the Tangiers area (fig.12).



**Fig. 12** : changes in the area of quarrying in the Haouz between 2003 and 2013

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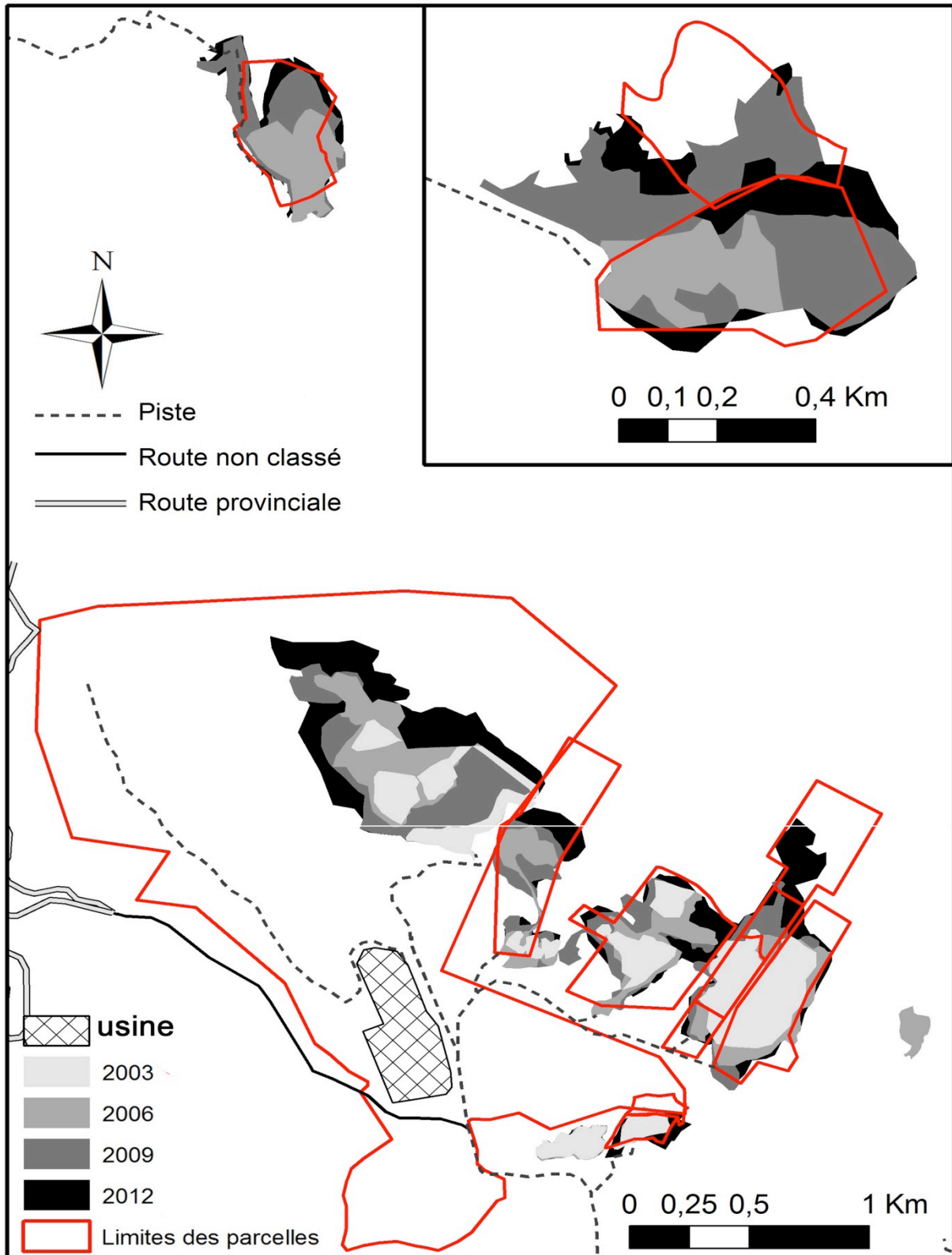


Fig. 13 : Evolution of the surface used in Saddina - khmis Anjra between 2003 and 2013

## CONCLUSION

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There is a large variation of quarries production, and comes from the inequitable needs from different sites.

We noticed also the non respect of boundaries compared with the delimitation provided by operators, and an uncontrolled exploration by Governments wish has resulted a massive extraction of geo-materials.

Finally we noticed that Saddina's quarries are well organized in both, limits respect and geo-materiel extraction, this is due to a the sectorial plan of the quarries made by rural commune of Saddena where has delimited the boundaries of each operator not to exceed.

The design of this database throughout the region of Tetouan, will help us to draw up the sectorial plan of materials on the region entire.

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