RECONSTITUTION OF THE SURFACE GEOLOGY OF OUARGLA BASIN-SOUTHERN ALGERIA BY REMOTE SENSING

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ABSTRACT - This work is the result of combination of remote sensing data, field work data, and the analytical data of the samples of the surface formations.Numerical processing made it possible to make a non-supervised classification, and then supervised classification, of the satellite image and to bring out at the end a thematic representation of the superficial geological formations according to their spectral signatures. This map is verified and validated on the basis of the land data (field visit and surface sampling data), analytical (physical and chemical analysis) and bibliographic data on the region in order to arrive at a map of the geology of the area of the study area.

Comparison of remote sensing data and field data has accomplished to the identification of the following surface and subsurface geological formation:

- Eolien sands medium to coarse;
- Silty sands fine to medium (alluvial sand);
- Pliocene Continental plateau;
- Silex gravel;
- Red Sandstone Mio-Pliocene;
- White gypsum Sables;
- Gypsum crusting;
- Saline wet soils;
- No soil surface (water surface and vegetation).

Keywords: Ouargla, remote sensing, soil, geology, geochemistry, surface formations.

INTRODUCTION:

Geological maps are essential tools for multiple applications. However, when running geological mapping, developers are faced with different problems. Restricted Access to outcrops (silting up, escarp terrain and private property), a period of limited mission (more or less favorable climatic conditions) all this problems generate a heterogeneity and discontinuity of the information collected.

Arid Saharan regions are often difficult to reach, and their mapping with ordinary methods (field visits, sampling ... etc.) are very long and increasingly unsustainable moreover the localized geological studies do not allow agencies responsible of development of these regions to understand rationally the very large areas of which they are charge.

To overcome these problems, the use of remote sensing data can be a significant source of information. Indeed each sensor measures a physical property of the earth's surface with specific characteristics (spatial resolution, spectral and radiometric camera angle, acquisition date and the Signal to Noise). The use of remote sensing data makes available information in digital form and all georeferenced in a single system.

The present work aims at the use of remote sensing for the cartography and the geochemical and mineralogical characterization of the surface of the soil in Saharan environment, it consists in first step with the discrimination of the surface formation of the surface then with the analysis and the characterization physico-chemical and mineralogical of each surface state apart.

I-Presentation of study area

According to their geomorphological, lithological and mineralogical characteristics the study site can be subdivided into five main units:

- The limestone plateau and reg (pliocene plateau);
- Aeolian sands (dunes and sandy sails of current age);
- The sandstone hills (the outcrops of the red sandstone Mio-Pliocene);
- Sebkha and saline soils (sebkha Safyoune and its surroundings);
- The old alluvial terraces. (Quaternary indifference).

I.1- Geographical situation:

The site concerned by this study is in the Northeast of the city of Ouargla and extends between the following geographical coordinates (Fig.1.):

X = 15 ° 15 '15 ° 4E;

Y = 32 ° 15'a32 ° 30, N.

It has a total area of almost 259872.5.ha (2599km2) which extends over a length of about 60km and 44km in width, facing South-West / North-East; limited:

- In the North by the city of Elhjira and slope of wadi N'sa;
- To the East by Ergs Touil and Arifdji road Ouargla-Hassi Mesouad;
- In the South the dunes of Sedrata and agglomeration of N'Goussa;
- To the West by the Wadi Wadi N'sa and Mzab (Fig.1.).

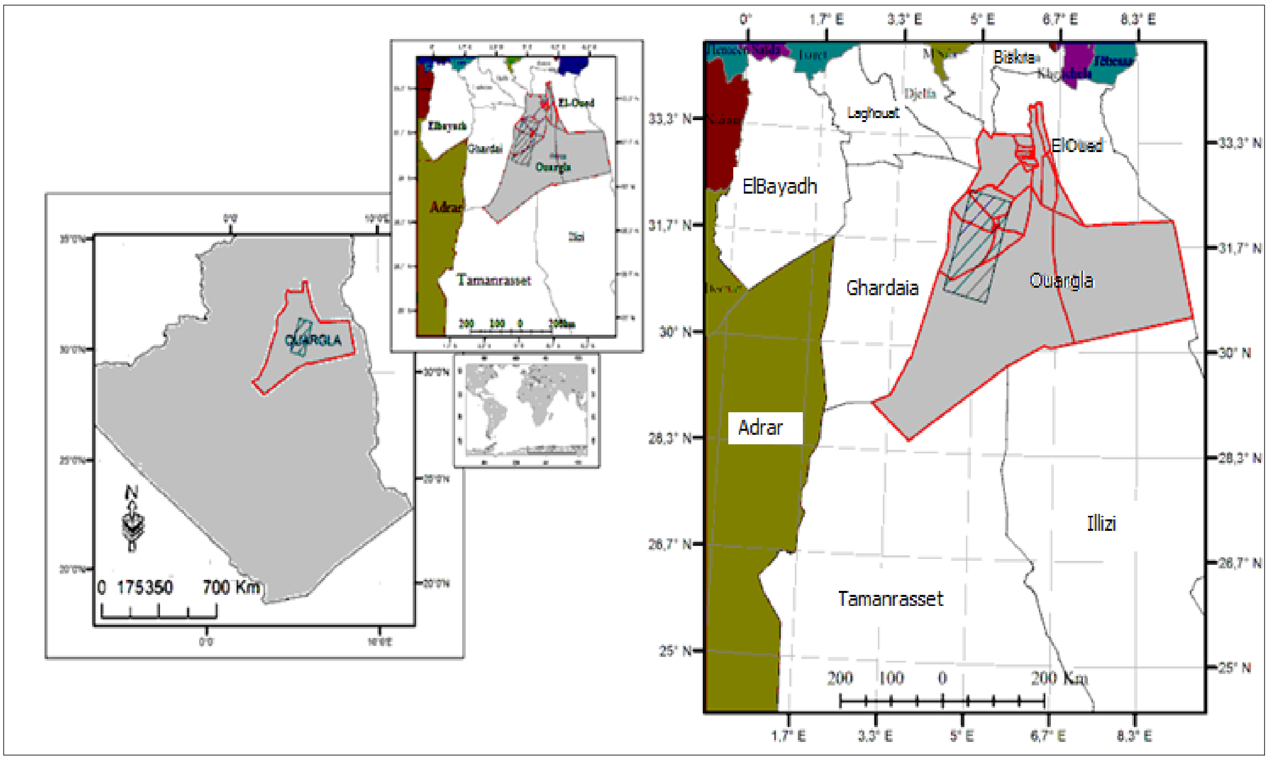


Fig.1: Geographical situation

I.2-Geological setting: Compared with northern Algeria, which is regarded as an unstable, complex and mobile region, the Sahara platform in the south is stable, monotonous and has been consolidated for hundreds of millions of years.
The Ouargla area is located in a sedimentary basin northeast of northern Sahara (Figure 2).

I.3-Geological outcrop: in our study area and the whole Ouargla region, only Mio Pliocene land is exposed, and they are covered by a low Quaternary sediment ("ERGs and dunes") (Figure 2).

II. Materials and methods:

In this study, the data compiled are as follows:

1-The geological map of the Mesozoic basin of the Algerian-Tunisian Sahara (1/2000,000), G. Busson (1967) **[1]**;

2- Image Land SAT ETM 7+ (p194r037_7t20010402_z31_xx) and Landsat-8 LDCM (LC81930372016167LGN00) 02 April 2001 and 03 July 2016, available in raster format (tif) with a resolution of 28 m **[2]**;

3- Geological map of Algeria (the sheet Constantine_sud) (1/500,000), MM.N. Gouskov and R.Laffitte 1951 service of the geological map of Algeria **[3]**.

4- The topographic maps of Ouargla and N'Goussa (1/200,000) Saharan maps) drawn up in 1956 by the US Army Map Service at the request of the National Geographic Institute;

5-Shuttle Radar Topography Mission (SRTM) with a resolution of 90m; (SRTM_u03_n031e000), available in raster (tif) format;

6-Physico-chemical, geochemical and mineralogical analysis data from surface and subsurface samples;

7-The investigation and site visit data (geological nature of the surface occupation, colour, texture, and structure ... .ect) are used later in verification and validation of the different treatments sustain the satellite images.

The document was developed following the following protocol: Integrating all of this data into a single GIS system involves a series of pre-processing and format conversions (Fig.3).

Field data (boreholes, wells, and image classification validation samples and rock samples) were located by a GPS system.

-The topographic information of SRTM data was used as a basis for the construction of the digital terrain model of the studied region.

- All TIF documents (Landsat images and SRTM data) are mosaicked to obtain a single document representative of the study area.

- The delineations of the geological formations are extracted by an algorithm of contours vectorization.

- The geological attributes are associated in a database with the vectorized contours of the formations

- The topographic background is superimposed on the geological formations (color formations) acquired by image processing.

- The vectorized map is manually edited and compared with pre-existing geological maps to eliminate possible confusion.

II.1- the investigation method

II.1.1-On the field:

We have previously highlighted the benefits of remote sensing in the exploration of natural resources but also its limitations that induce the need for field verification.

Two missions were conducted to the field of the study area. These were carried out in April 2011 and January 2012, respectively, to acquire information on the ground reality of different land and to identify them geographically by GPS. This information has played an important role in producing a list of superficial formations for supervised classifications.

II.1.2-At the laboratory:

1.2-2.1-Physical and chemical analyzes:

- Granulometric analyzes;
- Total limestone;
- Dosage of gypsum;
- Organic material ;
- Electrical conductivity;
- pH.

1.2-2.2- Mineralogical analysis: X-ray diffractometer (XRD) analysis, diffraction analysis was done in the physics laboratory using Philips X'Pert- MPD X-ray Diffraction System device. We analyzed powder samples representing the main surface formations.

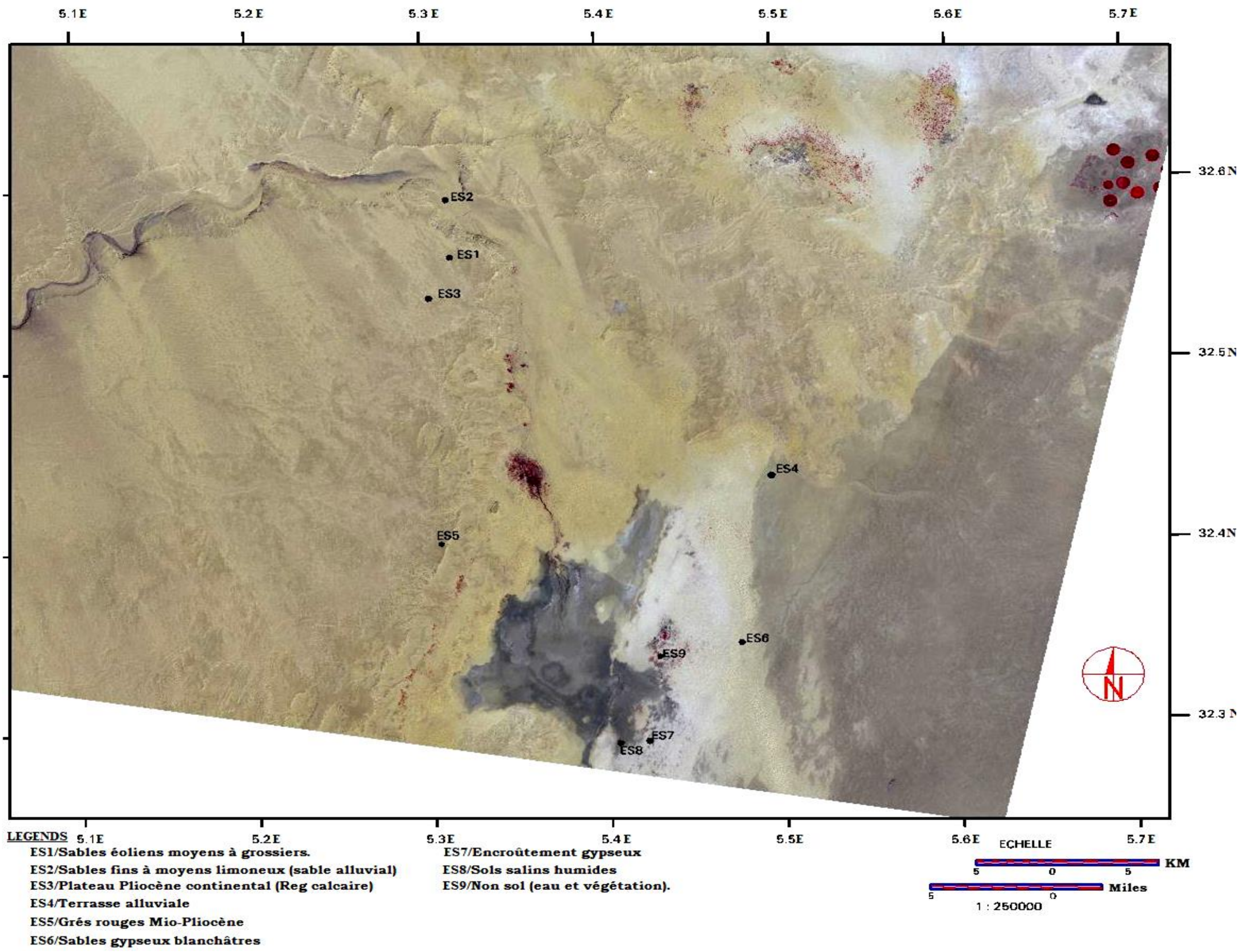


Fig. 2: samples Position plan

II.1.3- The satellite image

The image used in this study is a Landsat7 ETM7$^+$ satellite scene acquired on April 02, 2001. Table (1) show the characteristics of the image.

Scene number	P194 r 037
Acquisition Date	02.04.2001
Acquisition time	09 :35.43.71
Dimension	8637x7695x1[BSQ]
Size	66.523,758 bytes
Solar elevation	38.78 km
Solar azimuth	135.81

Tableau 1: Technical characteristics of the image used (P194r037)

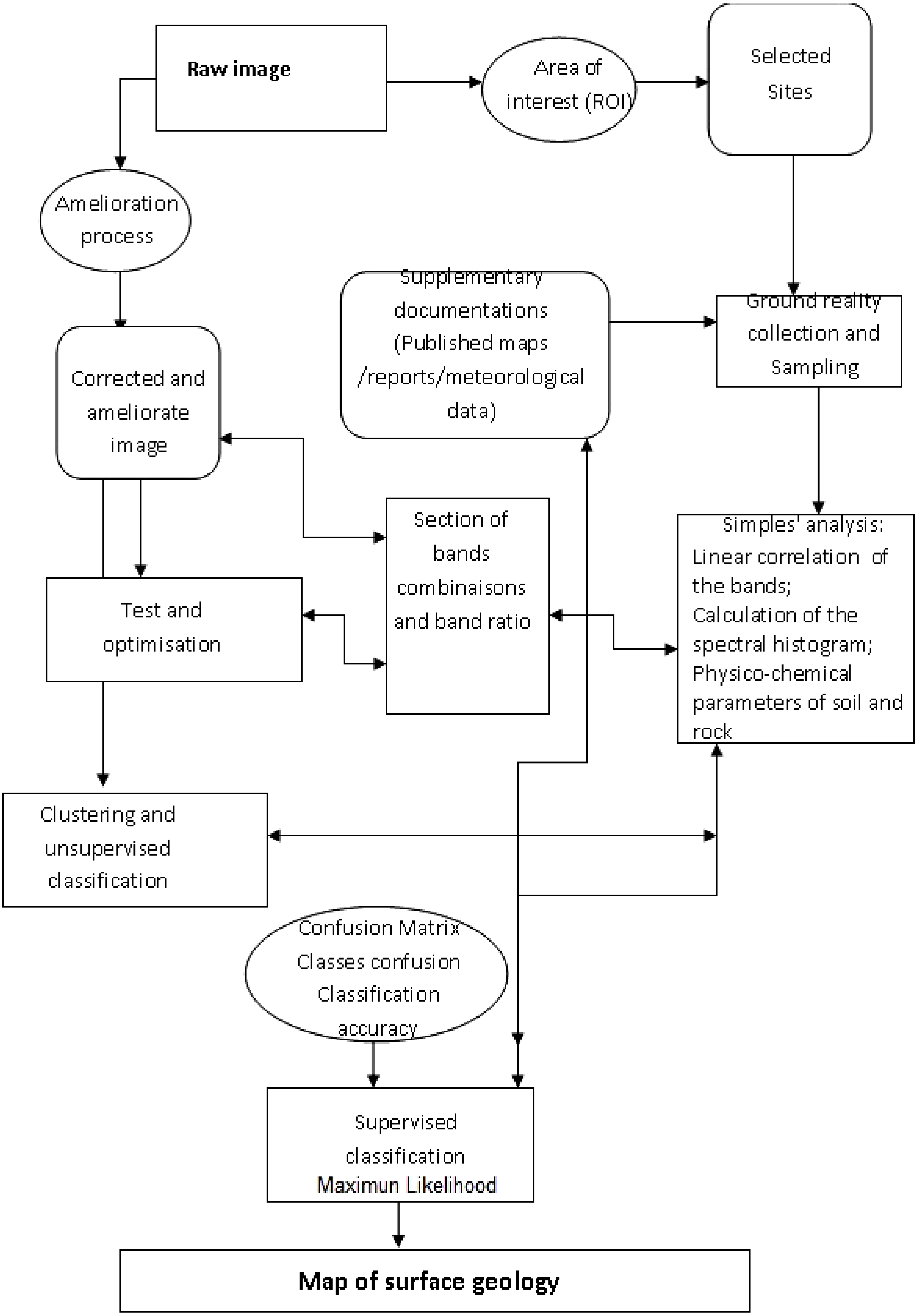


Fig.3: Chart of the steps of realization and material used in this study

III. Results and discussion:

As shown in Figure 5 and 6, in addition to water surfaces and vegetation, eight (8) surface formations were distinguished according to their dominant mineralogical expressed on the map by different colours:

1. The aeolian and alluvial sands formations (dominant quartz) appear clearly there, whatever their position in the region. The rougher ones, nebkas and aeolian sails are in yellow the finest are in pale yellow (fine alluvial sands) (Fig.5).

2- The gypseous formations: appear in two very well individualized classes, the first in cyan colour corresponds to the dissected gypseous reliefs and the gypsum encreatments, the other in pink (Fig.6) corresponds to the whitish gypsum sand which is the product of wind erosion of gypsum rock on sandstone hills and on the plateau (Fig.5).

3-Surfaces with wet saline soils and saline efflorescence: on the map correspond to the sky-blue color ranges (Fig.3), are saline soils with sandy texture, with many whitish spots and gypsum crystals, with brown to greyish dark color in dry stat (2.5Y4 / 2) (fig.5) no effervescence with HCl.

4-The limestone and dolomitic limestone formations: appear on the map in light brown (fig.5) and (fig.6) and correspond to the plateau material which is materialized by gravel and dolomitic limestone gravel from gray to light gray and blocks and micro-conglomeratic stone (sandstone, limestone sandstone and gypso-limestone). (Fig.4.). Another important parameter in the variation of the reflectance values of this type of surface formation is the phenomenon of pierrosite (coarse elements), most often the reflectance increases with the pierrosite. This is mainly because the energy reflected by the coarse elements, which often play like specular surfaces, is more important than the shadows they cause (GIRARD, M-C, GIRARD, CM, 1999) **[4].**

5- sandstone formations with carbonate cement appear on the map in olive green (Fig.6) they are materialized by the red sandstone substrate with Mio-Pliocene clay-carbonate cement (5YR 6/4) (fig.5) . The relatively low reflectance of this formation is mainly due to their dark-saturated color and the relatively high content of fine elements (slightly silty clay-silty cement sandstone).

6-The gravel flint formations are homogeneous surfaces, made of detritus siliceous material of centimeter size, very rounded mix into wind coarse quartz sand (Figure 5) and (fig.6). The low reflectance of this surface condition is probably due to the dark color of the constituents and to the homogeneous roughness of the surface of this formation. This formation appears in garnet on the map (Fig.6).

II.1-The spectral behaviours of the different geological formations of surfaces:

The spectral behaviour of objects is a privileged way to analyze and interpret remote sensing images because it is based on general physical laws, Girard MC and Girard C (1999) **[4].** The spectral responses of the classes that we have been able to highlight are illustrated in the figure (fig.4) which presents the curves of reflectance transmit from each class.

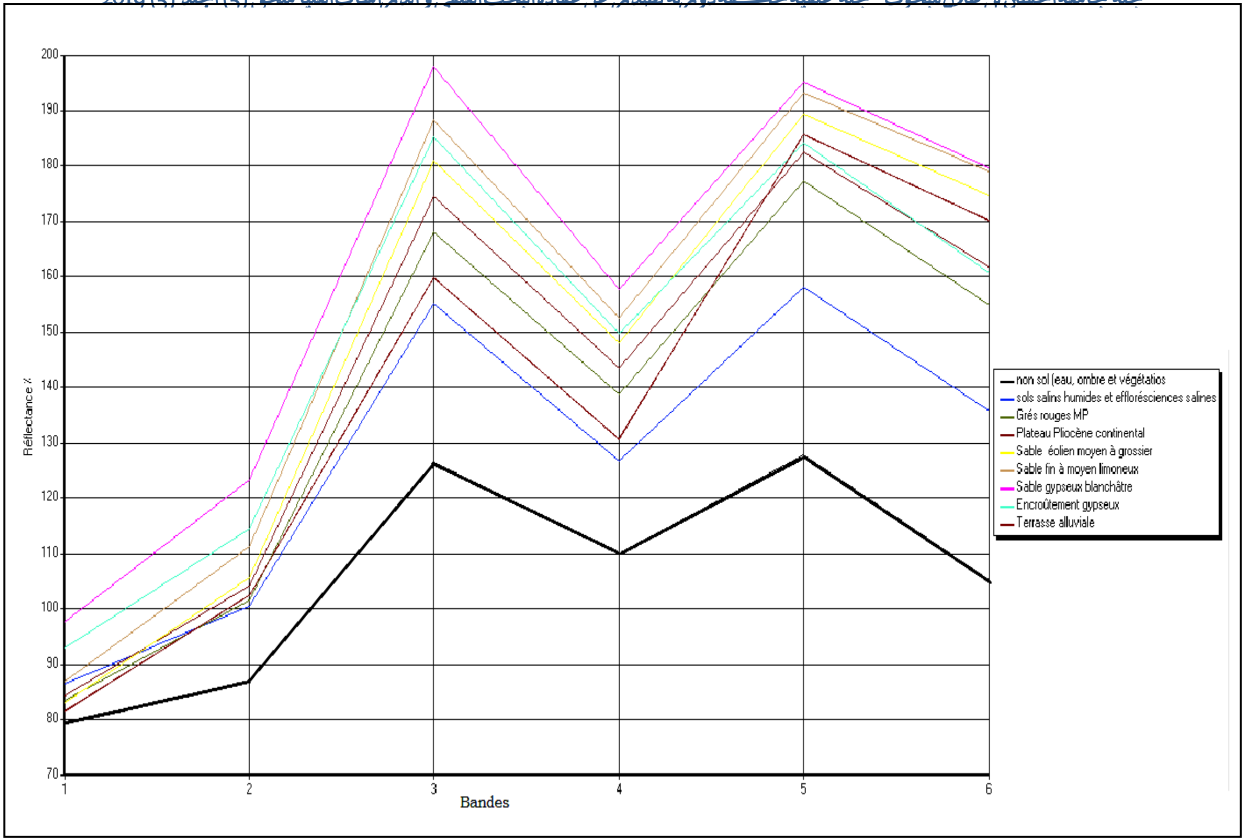


Fig. 4: The curves of the spectral signatures of the different formation of surfaces.

In this study, we will focus on the spectral behaviour of soils. We can also deduce from this figure (fig.4) that the varied reflectance according to the colour and the clarity of the soils:

- The greater the clarity, the stronger the reflectance;
- The lower the clarity, the lower the reflectance.

The strong reluctances in all the bands are those of clear, finest soils and dry soils (whitish gypsum sands, gypsum encrustation, aeolian and alluvial sands).
The lowest reflectances in all bands are those of dark, rough, wet and light absorbing surfaces (red sandstone, limestone plateau, alluvial terrace, wet saline soil, and sebkha water surfaces).

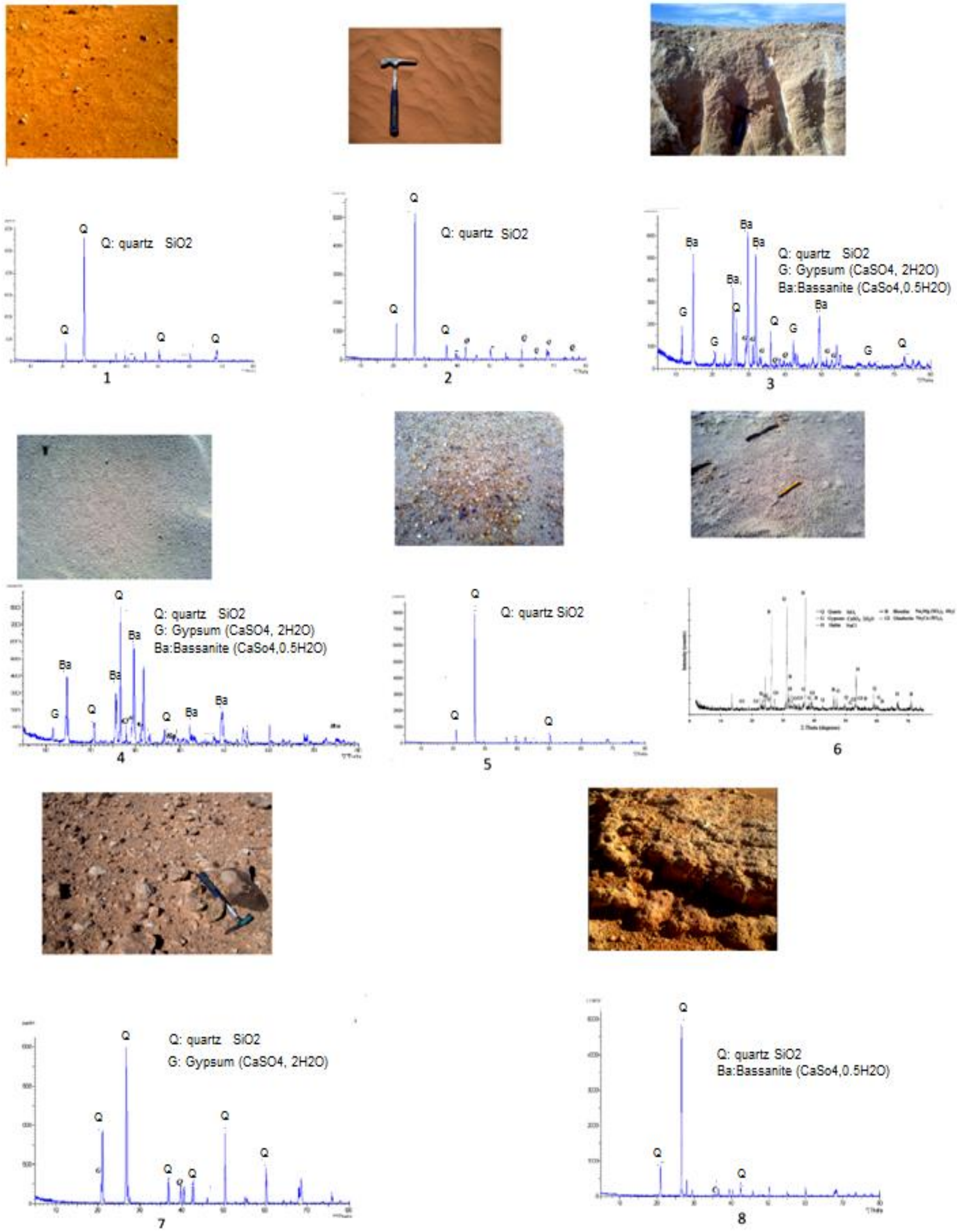
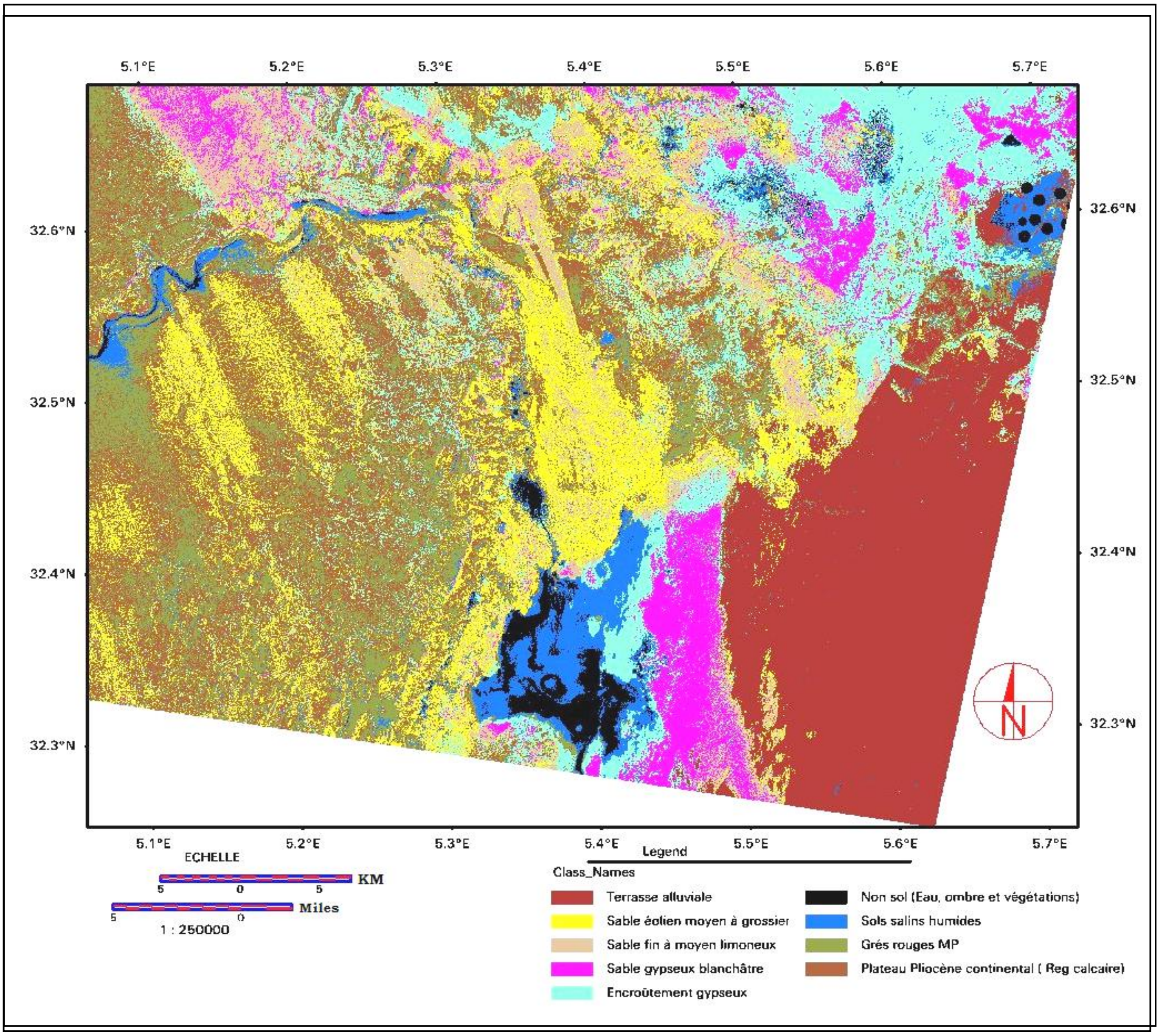


Fig.5: Photos and X-ray diffractograms of different surface geological formations: 1-surface formation of eolien sand medium to coarse sized, 2-surface formation with fine to medium silty sands; 3-surface formation with fine whitish gypsum sand; 4- flint gravel surface formation; 5- gypsum (polygonal and massive)



encrusting surface formation; 6 - surface formation: wet saline soils and saline efflorescence (Hamdi-Aissa, B. 2004) **[5]**; 7- continental Pliocene plateau surface formation (Reg limestone); 8- Surface red sandstone Mio-Pliocene.

Fig. 6: Final map of surface geological formations of the study area

Les fortes reflectances dans touts les bandes sont celles des sols claires, les plus fins et des sols secs (les sables gypseux blanchâtres, encroutement gypseux, les sables éoliens et alluviaux).

Les reflectances les plus faibles dans touts les bandes sont celles des surfaces de couleur sombre, rugueux, humides et surfaces absorbant de lumières (grés rouges, reg calcaire du plateau, terrasse alluviales, sols salins humides et surfaces d'eau de sebkha).

Conclusion:

After all cartographic generalization, pre-treatment and treatment operations, filtering and grouping of units, the final result was seven geological classes representing the main surface geological formations of the region. For each of these soil surface classes, the mineralogical associations that it could contain were deduced, with the help of field observations, physico-chemical, geochemical analyzes and theoretical knowledge on the genesis of soils in arid environments.

The comparison of the results of laboratory and remote sensing analyzes shows a very significant agreement and a strong correlation between the results obtained by the two methods (physico-chemical and mineralogical analyzes and remote sensing).

Indeed, the mineralogical composition of the superficial formations constitutes a real criterion of soil differentiation, measurable directly in the field, in the laboratory and observable by remote sensing.

In the end, we came up with a cartographic sketch on which the geologist and the soil scientist and other specialists will be able to rely to locate and delimit the large surface geological geological assemblages.

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