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MAPPING REMOVAL SWELLING CLAY SOILS IN THE AURES (N'GAOUS) ALGERIA

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Abstract: The shrinkage and swelling phenomena of certain clay soils cause differential settlement manifested by disorders that affect mainly the individual frame. The objective of this research was to create a map related to these phenomena especially in the area of Algeria N'gaous (figure 1). The approach of the study is primarily based firstly on the interpretation of a geological map at a scale 1 : 50 000 and on the other part from existing literature and observations on a synthesis of a large number of geotechnical information to determine susceptibility to the phenomenon of clay or marl formations. This approach consisted in the establishment of a synthetic departmental mapping of these formations that have been identified from a hierarchy as to their susceptibility according to the shrinkage and swelling phenomenon. This classification was established on the basis of three quantifiable main features: the dominant lithology of formations, the mineralogical composition of their clay fraction (proportion of swelling minerals) and geotechnical behavior (primarily assessed from the blue value and the plasticity index).

Key words: marl, smectite, shrinkage and swelling, natural risk, geotechnical mapping,

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INTRODUCTION

The phenomena of shrinkage and swelling clays are the source of many disorders in the frame and constitute the world's second leading cause of natural disasters compensation after floods. Indeed, alternating periods of drought and precipitation leads to changes in the soil water status resulting in displacement of shallow foundations induced by hydro-mechanical couplings.

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This alternation of withdrawals and swelling can cause damage in the built form of relatively large cracks or the partial or total disruption of that work, when not included in the projects.

The swelling clays are present in several regions of Algeria. The damage to infrastructure in this type of land totaling several billion dinars annually. These excessive damages are due in part to inappropriate design, resulting from the lack of tools to assess the impact of expansive soils in typical applications. This research work presents an experimental program and interpretations in order to establish an objective scientific fact and to have references to preventive information, to map this phenomenon in the region N'GAOUS to define the most exposed areas in shrinkage and swelling clays (AFNOR, 1998; Mamoune, 2002; Bekkouche, 2005; Derriche & Kaoua,1994; Djedid et al., 1997; Philipponnat, 1991).

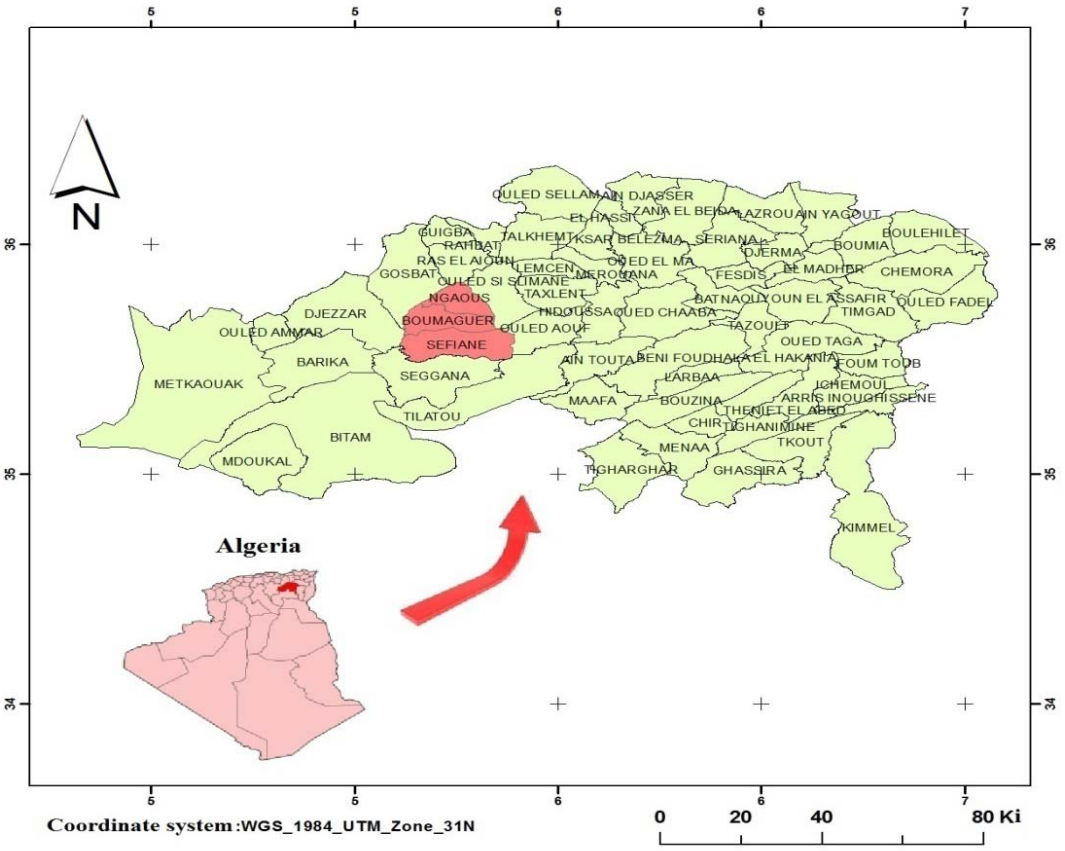

Figure 1. Presentation card of study area N'gaous Algeria Region

IDENTIFICATION AND MAPPING OF CLAY AND MARL N'GAOUS GEOLOGICAL FORMATIONS IN THE AREA

The goal is to have a map of geological formations and clay marl of N'gaous area to identify areas susceptible to shrinkage and swelling.

This work was carried out from the 1:50 000 geological maps covering the entire area from which we selected the clay and marl formations that may be prone to shrinkage and swelling phenomenon. It was identified 32 levels with this character on the area (table 1).

In some cases, the clay or marl constitute the major part of the retaining formation. But in most cases, the clay or marl geological formations N'gaous area is very heterogeneous; it could be criteria. The criteria for the development of the susceptibility map withdrawal - swelling

phenomenon are the lithology of the formations, the characterization of these formations depending on the mineralogical nature of these clays in the clay phase and the geotechnical behavior of the material. The susceptibility map and either intrinsically heterogeneous formations, which consist of a mixture of different materials including clays or marls, but also coarser elements (silts, sands, serious ...). This is particularly the case of alluvial formations, variegated sands and clays, clay, sand and sandstone Ypresian, black sands and clays. The clay is either mixed with the other constituents, either in the form of individualized levels, separated from each other by spacers of non-clay beds, distributed in a complex sequence and which may exhibit spatial variations. In these circumstances it is not possible, at the departmental level, to accurately distinguish the clay-containing those areas where it is completely absent, and all of these courses, for heterogeneous nature was considered like clay; or formations to the little clay base, but which, because of their alteration, present in many sectors clay facies, especially in the first few meters of soil. Again, due to the impossibility of distinguishing at the departmental level the contours of clay areas of those indurated zones (notably limestone), it was decided to consider all of these formations like clay, especially because of many claims they have caused.

The heterogeneity of this training course is taken into account in the characterization of susceptibility with respect to the shrinkage and swelling, particularly in the lithological rating (figure 2).

Table 1. List of clay and marl formations of the Region N'gaous

N°	Code	Geological formation name
1	m3b	gypsum marl and sandstone
2	c2b	Calcareous-marl alternations
3	c2a	limestone and flint rudist
4	c1d	Saccharoides dolomites, massive Claires
5	c5-6a	marls with small limestone beds
6	c3-4	marls with small limestone beds
7	m1	red pudding and marnolites
8	m4	Sanders brown marl, sandstone, gypsum
9	p1-2	sandstone and sandy loams
10	q4	coarse conglomerate
11	m2-3	conglomerates, breccias, limestones has lithothamniées
12	t3	compact limestone and crusts
13	t6	soft carbonate deposits
14	t4	porous limestone and crusts
15	q5	sandy clay to calcareous dolls
16	q	undifferentiated quaternary
17	q6	silts, conglomerates
18	t5	porous limestone powder, white
19	t7	very soft clay deposits -carbonatés
20	q6-7	silt, pebbles and sand, conglomerates
21	q2	very coarse conglomerate
22	q3	very coarse conglomerate
23	m3a	limestones lithomanieés
25	c2b	Calcareous-marl alternations
26	m2a	calcareous conglomerates lithothamniées
27	éboulis	scree
28	terrasse	teracce
29	q5-6	sandy clay to calcareous dolls, silts
30	q1	conglomerate block
31	q7	silt, pebbles and sand
32	m2b	sandy marl and calcareous marl

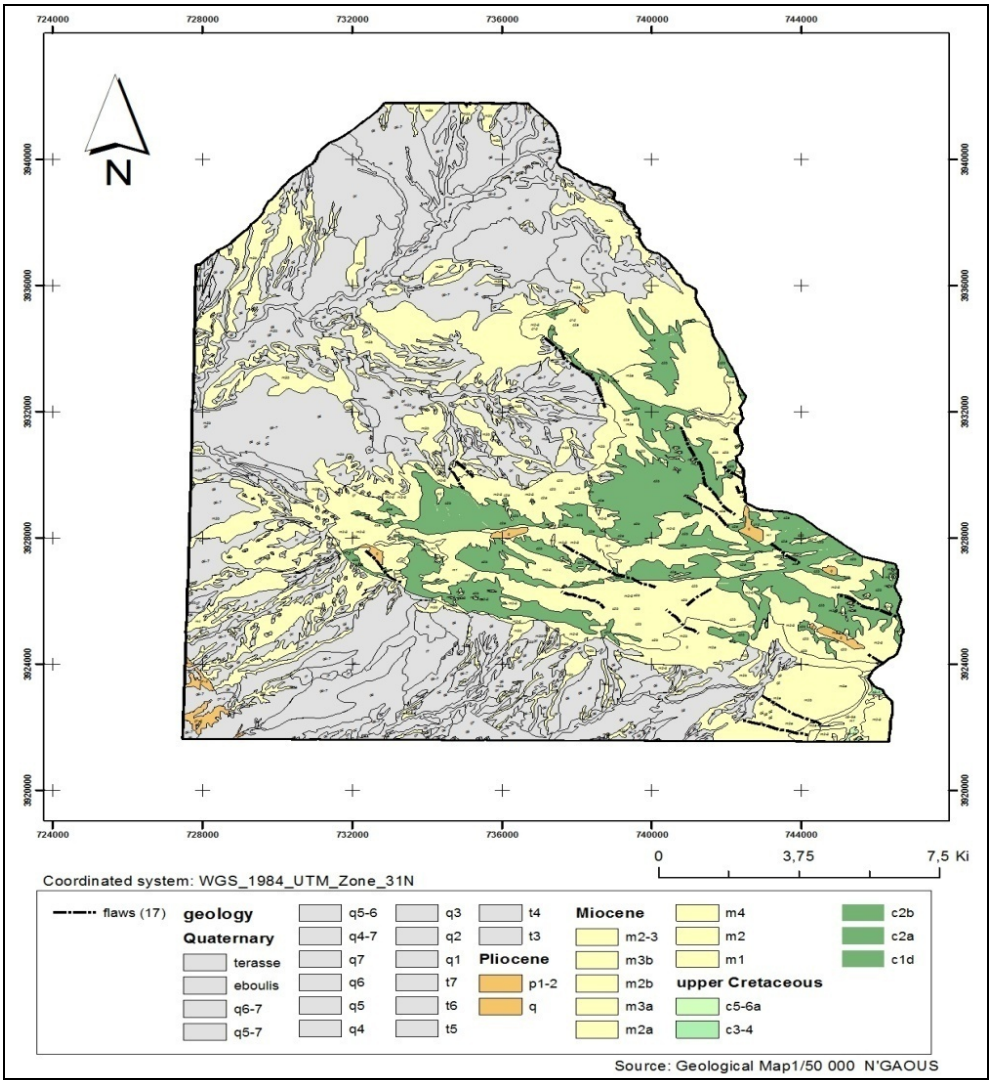

Figure 2. Geological Map of the Region N'gaous

CHARACTERIZATION LITHOLOGICAL, MINERALOGICAL AND GEOTECHNICAL CLAY FORMATIONS - DEVELOPING THE SUSCEPTIBILITY MAP

Criteria

The criteria for the development of the susceptibility map withdrawal-swelling phenomenon are the lithology of the formations, the characterization of these formations depending on the mineralogical nature of these clays in the clay phase and the geotechnical behavior of the material. The susceptibility map and developed corresponds to a prioritization of identified geological formations, taking into account only these three criteria.

Classification procedure

We remember that the basic document used to develop the susceptibility map is the synthetic clay and marl map courses of the department, which was established with primary nature of the lithological formations.

The second step of this mapping is to prioritize training marly clay and thus identified, based on their greater or lesser susceptibility according to the shrinkage and swelling phenomenon.

This ranking is based on the consideration of quantifiable characteristics, estimated for each of the 31 selected courses:

- the lithology of the land constituting the majority of training;
- the mineralogical composition of the clay fraction, assessed from the proportion of swelling minerals;
- the geotechnical behavior of the material, evaluated primarily from the reactivity of the soil respecting water (characterized by the value of blue, the extent of its plastic domain (characterized by its plasticity index).

In order to obtain a practical way to prioritization between the different formations, the rule adopted was to use threshold values commonly accepted in the literature, distinguishing four levels of sensitivity (low, medium, high and very high). To enable the realization of calculations, large distinguished lithological classes were also affected by a note. For the three natural features of the land, this allows to assign a score from 1 to 4 in each of marl or clay formations identified in (table 2).

Criteria lithology

Table 2. The scale used to distinguish the different lithological classes is:

Formation type	Susceptibility	Lithologic Note
Non-clay formation but locally containing past or clay pockets (eg alluvium with clay lenses, limestone pockets karst, ...)	low	1
Training with a term not predominant clay or sandy clay calcareous clayey	average	2
Training predominantly clay, with a term or not passed clay (eg alternating marl limestone or sandy clay) or very thin (within 3 m)	forte	3
Mainly clay marl or training, over 3 m in thickness and continuous	very strong	4

The classification following lithological rating highlights the fact that among the 32 clay or marl geological department (table 3):

- 3 training get a rating of 3, which means that their clay component is dominant;
- 8 formations obtain a score of 2, which means that the term clay is not predominant;
- 15 trainings get a rating of 1, indicating that the clay are terms that are present very locally;
- no training has been rated 4.

Table 3. The scores for each lithological formations are presented below

N°	Code	Name of the geological formation	lithological Note
1	m3b	gypsum marl and sandstone	2
2	c2b	Calcareous-marl alternations	3
3	c2a	limestone and flint rudist	1
4	c1d	Saccharoides dolomites, massive Claires	0
5	c5-6a	marls with small limestone beds	2
6	c3-4	marls with small limestone beds	2
7	m1	red pudding and marnolites	0
8	m4	Sanders brown marl, sandstone, gypsum	2
9	p1-2	sandstone and sandy loams	2
10	q4	coarse conglomerate	1
11	m2-3	conglomerates, breccias, limestones has lithothamniées	1

12	t3	compact limestone and crusts	0
13	t6	soft carbonate deposits	1
14	t4	porous limestone and crusts	1
15	q5	a calcareous sandy clay dolls	2
16	q	undifferentiated quaternary	1
17	q6	silts, conglomerates	1
18	t5	porous limestone powder, white	1
19	t7	very soft clay deposits -carbonatés	3
20	q6-7	silt, pebbles and sand, conglomerates	1
21	q2	very coarse conglomerate	1
22	q3	very coarse conglomerate	1
23	m3a	limestones lithomanieés	0
25	c2b	Calcareous-marl alternations	3
26	m2a	calcareous conglomerates lithothamniées	0
27	scree	scree	1
28	terrace	terrace	1
29	q5-6	a calcareous sandy clay dolls, silts	2
30	q1	conglomerate blocks	1
31	q7	limon, galets et sables	1
32	m2b	marnes et marno-calcaires sableux	2

CARACTERISATION MINERALOGIQUE CLAY FORMATIONS

Chemical analysis: This analysis included the determination of the chemical nature of the clay N'Gaous to study. In this context, a quantitative chemical analysis by XRF was determined; the results are summarized in the table below:

Table 4. Chemical composition of N'Gaous clay

Chemical composition	Quantities (%)
Silica [SiO2]	41,78
alumina [Al2O3]	17,43
Iron oxide [Fe2O3]	7,43
Calcium carbonate	7,92
[CaCO3]	7,32
Lime [CaO]	2,72
Magnesia [MgO]	0,02
sulfur trioxide [SO3]	2,03
K2O	0,37
Na2O	0,02

Thus, the quantitative chemical analysis reveals that:

- the sample contains an amount of 41.78% silica [SiO2] well below 80% which is the border of expansive soils and non-swelling;
- the rate of calcium carbonate [CaCO3] is 7.92% so that the clay to be tested is actually clay;
- the rate of sulfuric anhydride [SO3] is 0.02% so that the clay to be studied is not aggressive reality.

MAP SUSCEPTIBILITY

Map of the susceptibility region was drawn from the synthetic clay and marl map of formations, assigning to each of geological susceptibility class defined above. The white areas of the map correspond to the non-argillaceous formations a priori, and therefore theoretically not subject to shrinkage and swelling phenomenon. However, one cannot exclude that these formations are covered locally superficial veneer of clay or contain pockets of clay, not drawn to

scale geological map of the current. These elements are linked in particular to formations of heterogeneity of mainly sand may locally contain clay lenses or alteration of carbonate formations.

Clay and marl formations are represented by two colors (yellow or orange) according to their respective degree of susceptibility increasing the phenomenon of low and moderate shrinkage and swelling (figure 3).

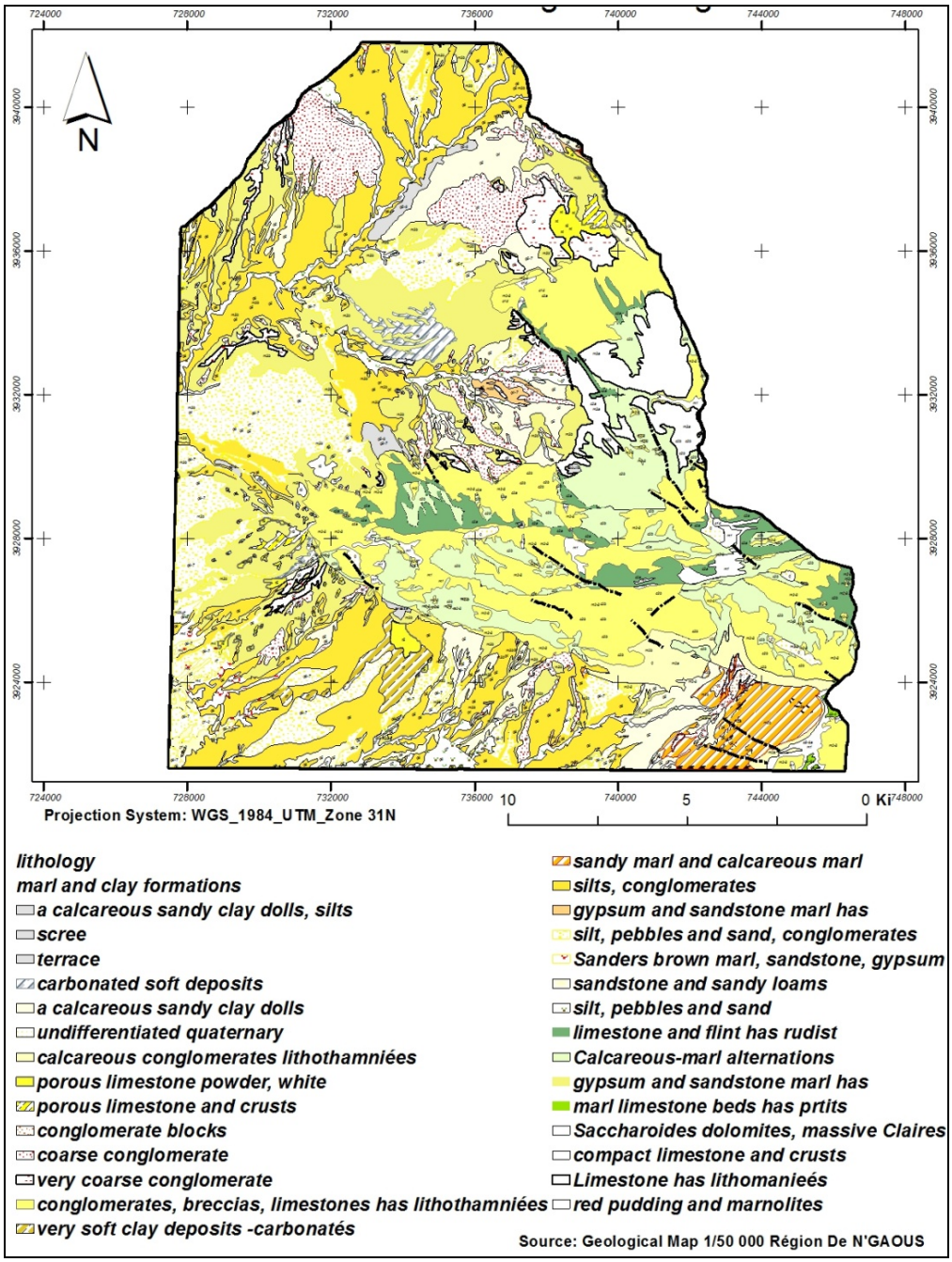

Figure 3. Geological map of training component has Clayey or Marl in the Region of N'gaous

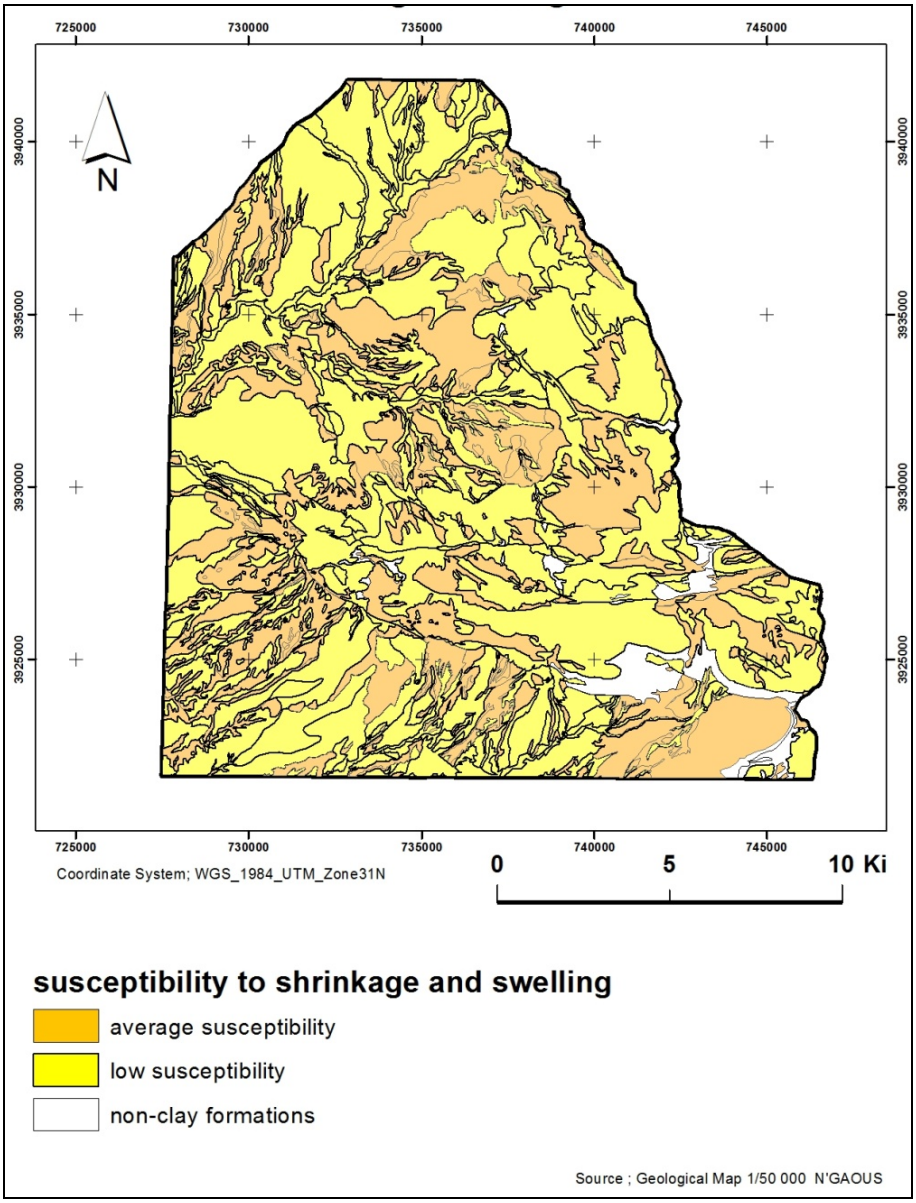

Figure 4. Map susceptibility to shrinkage and swelling clays in Region of N'gaous

Table 5. Training susceptibility Degree

N°	Code	Name of the geological formation	Note lithological	Note mineralogical	Note géotechnique	Moyenne	Degree of susceptibility
1	m3b	gypsum marl and sandstone	2	2	3	2,33	average
2	c2b	Calcareous-marl alternations	3	2	3	2,67	average
3	c2a	Limestone and flint rudist	1	2	3	2,00	weak
4	c1d	Saccharoides dolomites, massive Claires	0	0	0	-	

5	c5-6a	marls with small limestone beds	2	2	3	2,33	average
6	c3-4	marls with small limestone beds	2	2	3	2,33	average
7	m1	red pudding and marnolites	0	0	0	-	
8	m4	Sanders brown marl, sandstone, gypsum	2	2	3	2,33	average
9	p1-2	sandstone and sandy loams	2	2	3	2,33	average
10	q4	coarse conglomerate	1	2	3	2,00	weak
11	m2-3	conglomerates, breccias, limestones lithothamniées	1	2	3	2,00	weak
12	t3	compact limestone and crusts	0	2	3	1,67	weak
13	t6	soft carbonate deposits	1	2	3	2,00	weak
14	t4	porous limestone and crusts	1	2	3	2,00	weak
15	q5	sandy clay to calcareous dolls	2	2	3	2,33	average
16	q	undifferentiated quaternary	1	2	3	2,00	weak
17	q6	silts, conglomerates	1	2	3	2,00	weak
18	t5	porous limestone powder, white	1	2	3	2,00	weak
19	t7	very soft clay deposits -carbonatés	3	2	3	2,67	average
20	q6-7	silt, pebbles and sand, conglomerates	1	2	3	2,00	weak
21	q2	very coarse conglomerate	1	2	3	2,00	weak
22	q3	very coarse conglomerate	1	2	3	2,00	weak
23	m3a	limestones lithomaniées	0	2	3	1 ,67	weak
24	c2b	Calcareous-marl alternations	3	2	3	2,67	average
25	m2a	calcareous conglomerates lithothamniées	0	0	0	-	
26	scree	scree	1	2	3	2,00	weak
27	terrace	terrace	1	2	3	2,00	weak
28	q5-6	sandy clay to calcareous dolls, silts	2	2	3	2,33	average
29	q1	conglomerate blocks	1	2	3	2,00	weak
30	q7	silt, pebbles and sand	1	2	3	2,00	weak
31	m2b	sandy marl and calcareous marl	2	2	3	2,33	average

CONCLUSION

The objective of this study was to establish maps on the phenomenon of shrinkage and swelling of clay soils in the N'Gaous region (Algeria). The approach is essentially based on an interpretation of the geological map and the synthesis of a large amount of information regarding susceptibility to the phenomenon of predominantly clay formations.

Synthetic map identifies the final 32 clay and marl formations, one of whose characteristics is the high heterogeneity related to their training condition or weathering.

The training was identified and prioritized according to their susceptibility to shrinkage and swelling phenomenon.

This classification was established on the basis of three main quantifiable characteristics (nature lithological, mineralogical composition and geotechnical behavior of soils). In addition, some factors of purely local expansion, such as tree vegetation, some human actions defects or foundation, were not taken into account as part of a study conducted. Others, such as the hydrogeological context, the geographical distribution of water deficits and topographic configuration were not considered sufficiently discriminating to be considered in the development of the mapping of the area

Ultimately, this card could serve as a basis for preventive actions information in the most affected by the phenomenon Commons. It would also be a prerequisite for the development of the Natural Hazards Prevention Plans (PPR), to attract the attention of builders and building owners on the need to respect certain preventive building codes in areas. This regulatory tool should

emphasize the importance of a geotechnical study as a prerequisite for any new construction in areas affected by the geological formations with high, medium and low susceptibility, particularly because of their strong heterogeneity. Otherwise, it should implement constructive rules to reduce the risk of occurrence of claims.

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