KINGDOM OF LIBYA

PEDOLOGY
and
PEDOLOGICAL SURVEY

by

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GENERAL PART AND

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C H A P T E R I

PEDOLOGY . TIME SCHEDULE

MAY .

- 2Ith. Arrival in Tripoli
- 22th. Talks with MM. Stepanovich, Stoyanovich and Peykovich, in the Ministry of Agriculture
- 23th. Talks in N.A.S.A. Office with Mr Haefeli and Mrs Cositch
- 24th. Talks with Mr Essat Abdul Wahab and with Mr Price, in the N.A.S.A. office.
- 25th. Work in the office (Ministry of Planning and Development).
- 26th. Friday.
- 27th. Works in the N.A.S.A. Office.
- 28th. Talks with Mr Heider in the N.A.S.A. Office.

  Visit to Sidi Mesri (Chemical Laboratory), and talk with Mr Ajshrart, director, and with Dr.,Pietri.
- 29th. Work in the office (Ministry of Planning).
- 30th. Visit to the Botanic Department of the University, and talk with Pr. Loufti Boulos (botanist).

3Ist. Talk with Mr. Price (N.A.S.A.) and work in the office.

JUNE .

- 1st. Work in the office .
- 2nd. Friday .
- 3rd. Work in the office .
- 4th. Work in the Ministry of Agriculture, and talk with Mr Hassadi and Mr Stepanovich.
- 5th. Trip to Wadi Megennin area under the direction of Mr. Grodjasky, engineer .

- 6-10th. Work in the office (Ministry of Planning).

- 11th. Meeting with Mr. Hassadi and Mr. Stepanovich (Ministry of Agriculture)

- 12th. Meeting with Mr. Ghiblawi, Mr Hassadi and Mr Stepanovich in the Ministry of Planning and Development .

- 13, 14, 15th. Work in the office .

- 16th. Friday .

- 17th. Benghazi. Talks with Mr. Ramadan, A. Sultant, regional director, and Mr. Fadil Gedefi, in Ministry of Planning and Development.

Mr. Yacine Samarai (pedologist), and

Mr. Abderrahman Haba (erosionist) in N.A.S.A.

Mr. Ibrahim Ben Kahiroun (director) and Mr. Feraj Gebril, in Ministry of Agriculture.

During the afternoon, trip to Coeffia .

- 18th.19th.20th. Trip to Barce, Beida, Apolonia and Qabat.

- 21 - 27th. Writing the preliminary report.

- 28th. Typing. Work in the office.

- 29th. Work in the office.

JULY .

- 1st to 10th. Writing the final report.

- 11th. Discussing the preliminary report (in Ministry of Planning with :

Mr. Ghiblawi (Min. of Planning)

Mr. Moussak "

Mr. Hassadi (Ministry of Agriculture)

Pr Stepanovich "

Mr. Stoyanovich "

Mr. Essat (N.A.S.A.)

Mr.Heider

Mr. Price

12th. Writing the final report.

- 13th. Discussing the preliminary report with the same people as on 11th. except Mr. Essat and Mr. Hider.

- 15th-16th. Writing the final report.

- I7th. Meeting in Ministry of Planning and Development concerning a model of tender document with :

Mr. Hassadi

Mr. Stepanovich

Mr. Stoyanovich

Mr. Moussa

- I8th-20th. Writing final report

- 22th-27th. Writing final report

- 29th-31st. Writing final report

AUGUST .

- 1st. Coming back to France

(From 3rd August to 3rd September, leave of absence by doctor prescription)

SEPTEMBER .

- 4th-6th. Writing final report

- 7th. Meeting with one expert regarding work in oasies

- 8th-9th. Writing final report

- 11th. Meeting experts concerning phyto-ecological and pedological study

- I2th. Meeting expert regarding study at scale of 1/50,000

- I3th-26th. Writing final report and end of the report

CHAPTER II

VARIOUS STUDIES PREVIOUSLY MADE ABOUT SOILS

1. GENERAL SOIL SURVEY STUDIES

1.1. Study of Stewart in Tripolitania.

This study is concerning Geffara (except the Western part), Djebel Nefusa (West Mountains), Homs and Misurata areas. It is including the whole part of the country where rainfall is exceeding 150 mm. per year and there is noticeable agricultural husbandry.

The report was not located or seen, therefore, it is impossible to know if a soil classification was used.

Still land use map is existing including twenty sheets at the scale of 1/100.000 ; it was drawn on the Anglo-Italian topographical map at the same scale as basic map.

Two sets of that map were seen ; one in the Ministry of Planning and Development (Tripoli) ; the other unclassified in a shelter in the Library at Sidi Mesri.

It does not appear that a pedological map and land capability map were furnished at the same time.

As a matter of fact, the land use map of Stewart give many data about agricultural activities, rocky and sandy areas, etc..

1.2. Study in Cyrenaica of Hubert.

This general soil survey, done by Food and Agricultural Organization in 1964, in the Green Mountains (Djebel Agdhar) of Cyrenaica, consists of a report amounting about sixty pages.

Hubert gave a precise classification of the soils encountered with an estimate of their agricultural value.

Soil profiles are well described, but no soil analyses were quoted in that report.

Some written informations seem to imply, at least, a sketch map that was attached to the report, but this map had disappeared from the consulted report.

Alien companies, working in Cyrenaica, have apparently used this map, but the information resulting from shows that this map is made at a very short scale and is not available for semi-detailed and detailed soil survey.

2. SEPARATE STUDIES AT MIDDLE AND LARGE SCALE

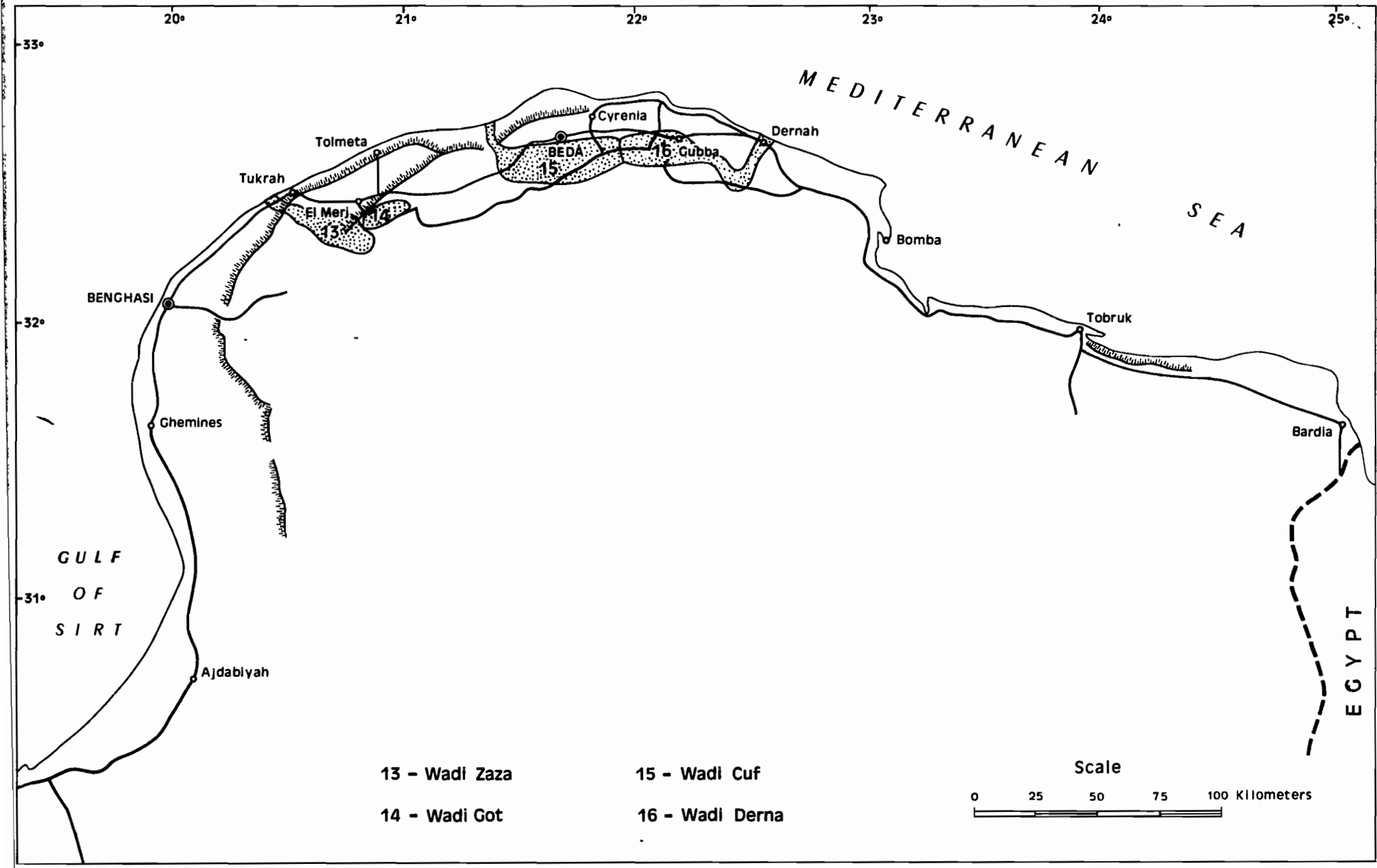
Some watersheds and areas were studied by foreign companies, chiefly in a way of preliminary studies about hydrogeology, hydrology and water and soil conservation.

2.1. Description on these studies

Company	Location	Area Km2	Scale	Land capability map	Other maps
Tripolitania					
Hidroprojekat	W. Megenin	952	1/100,000	Yes	texture
	W. Cherua	388	1/50,000	Yes	texture
	W. Gsea	615	1/50,000	Yes	texture
	W. Rambl, Msid & Turgut	1100	1/100,000	Yes	texture
	W. Lebda	195	1/50,000	No	erosion
	W. Etel	274	1/50,000	Yes	texture
Mac-Laren	W. El Hira	300	1/100,000	Yes	texture
Wakuti	Tauorga	31	1/10,000	Yes	soil units without name
Hunting	Bir el Ghnem	549	1/100,000	Yes	erosion, soil units with vernacular names
Termec Libya	W. Caam	897	1/10,000	Yes	texture, soil units without names
Total		5,401 Km2			
Cyrenaica					
Hidroprojekat	W. Derna	585	1/100,000	No	land use
	W. Cuf	986	1/100,000	Sketch map	land use
Ifagraria	W. Got	175	1/66,000	No	land use
	W. Zaza	640	1/100,000	No	land use and a land use-texture combination
Total		3,386 Km2			

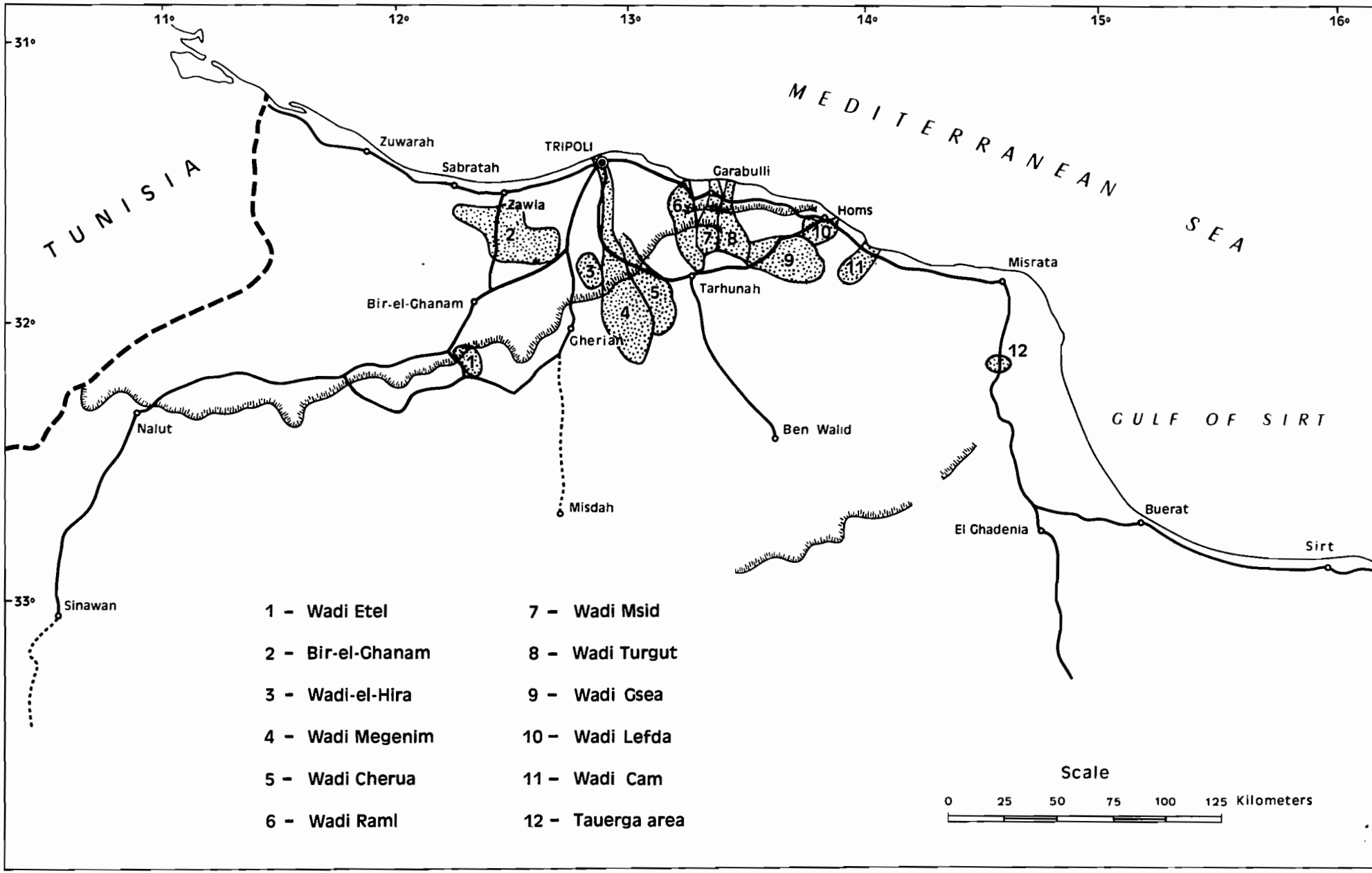
N.B. : Another company "Nuovo Castoro", had studied at the scale 1/100,000 about hundred sq. Km. in the areas of Farzouga, Bata, Mesa, Guirnada and Goulak in Cyrenaica.

Final documents would be reports and land capability maps ; these documents were not available, because this company had worked under direct contract with the NASA (National Agricultural Settlement Authority).



CYRENAICA

AREAS WHERE VARIOUS WORKS IN CATCHMENT STUDY WERE MADE



TRIPOLITANIA

AREAS WHERE VARIOUS WORKS IN CATCHMENT STUDY WERE MADE

2.2. Qualities and deficiencies of these studies

Except in Wadi Caam and Tauorga area, the main purpose of the companies was hydrology and water conservation ; soils were only studied according to the mentioned purpose (erosion, land use, texture) ; apparently pedology is a subordinate affair.

Land capability map and erosion maps appear well made ; often some analyses of soils are existing. The general part indicating natural factors (climate, vegetation, parent material, etc..) is fairly well developped. Unfortunately, there is no pedological map and soil classification. This gap is very important in a normal way, at first classifying soils on pedological map and then with basic data obtained by drawing a land capability map.

Land capability map established by foreign companies will likely show any inadequacy in the future.

One company used vernacular names in soil mapping, which is indeed an interesting way, but it is not possible to be compared with soils from other countries.

Two companies have delineated soil units naming in number : but every soil classification is rather based under names that in numbers.

When some analyses are existing, they are rarely large enough to particularize each soil unit ; besides analyses methods are American, German, Italian, etc., according to the nationality in every company. Often it is rather difficult to make comparison between analyses data of one watershed and another.

Soil profiles are described carefully with processes commonly used by pedologist ; but it is pity that only some scientist are using American Munsell Colour Chart to determine soil colour ; although this chart is commonly employed in soil science.

A serious deficiency of all these studies is the fact that final documents are not homogeneous from one company to another : reports are amounting from one page (then it is a very short summary), to fourty according to the study ; maps annexed are not always the same in shape and quality.

In Tripolitania, we found many good land capability map and often erosion map, but in Cyrenaica, there are often land use maps only. This deficiency would be balanced by synthesis map, but it is done not quite often.

Conclusion concerning separate studies.

Various studies already done by private firms had covered in Tripolitani and in Cyrenaica a total area of about 9000 sq. Km.

So that kind of work is important, but is often deficient, chiefly about the following points :

- soils classification absent
- pedological maps lacking or including only numbers or vernacular names
- analyses : insufficient number
- methods of analyses different from one company to another
- documents : non homogeneous information.

We must stress on the fact that many companies were not bound to carry out precise pedological work and that their main purpose was especially hydrological : pedological study succintly made as a complement of their work does not appear as requested on a proper form.

3. DETAILED STUDIES FOR LAND ASSESSMENT

3.1. Generalities

These studies are made in large scale, 1/15,000, 1/10,000, 1/5,000, according to topographical map availability ; the best scales are 1/5,000 and 1/10,000°.

In Kingdom of Libya, two authorities are adjusting these studies which come just before land reclamation : Ministry of Agriculture and National Agricultural Settlement Authority (NASA).

3.2. Ministry of Agriculture studies

Studies recently started after the arrival of one pedologist employed by the Ministry ; they are concerning three Fezzan oases : Traghen, Sebha and Brach.

3.3. N.A.S.A. studies

Studies already done or in a course to be continued are bearing upon (Ministry of Planning and Development Information) :

Tripolitania	26 811 Has
Cyrenaica	22 084 Has
Fezzan	1 000 Has

Some of these soil studies would be entirely done, that is to say : Collina Verde, El Hania, Useta, Bu Traba, Gianduba, in Tripolitania and Coefia, Benina, Farzouga, Bata, Messa, Guernada, Goulah in Cyrenaica.

These five last studies were made at 1/5,000 ° scale by Nuovo Castoro Company and are amounting to 1721 hectares (oral information from NASA in Benghazi).

But, in general, it was impossible to obtain exact information about each project location surface or scale, etc..

3.4. Difficulties of study at large scale

Various experts, working on land reclamation in Libya, appear to have inconveniencies by the following gaps :

a) Topographical maps in available scale are often lacking. For example, among forty NASA projects, thirty five are wanting for basic maps in available scale.

b) Aerial photographs are often lacking : among those 40 NASA projects, 25 are wanting for aerial photographs.

c) Pedological documents at scales of general or semi-detailed survey are lacking in several cases.

1/50,000° scale is generally admitted to be good by experts working in Libya.

1/100,000 scale would be sufficient. Unfortunately there are only a few numbers of land capability map at such scales.

d) Soil analyses take a long time to be obtained : those analyses are usually made by Sidi Mesri Laboratory, which the staff materials and premises are limited for such purpose..

Sidi Mesri Laboratory is not only a laboratory for soil analyses, but is also concerned with organical analyses (sugar-beet analyses in June 1967) and check assay concerning smuggling in imported goods. Therefore from three to six months delays are common for soil analyses requested by pedologist.

Conclusion for large scale studies for land reclamation.

Those studies indeed are commenced, but they are suffering from the four deficiencies above-mentioned.

Often soil scientists are obliged to make additional works beside their technical specialities. They waste their own time, and government loose money.

CHAPTER III

MAPS AND AERIAL PHOTOS OF LIBYA

to be used for pedological purposes

Existing maps

- 1/2,000,000 - U.S.G.S. One sheet for all Libya
- 1/250,000 - U.S. AMS 1958 - 1964 - 57 sheets of the Northern part and Western border of Libya. Each map corresponds to 1.5. square degree (15700 sq. Km.)
- 1/50,000 - U.S. AMS - 1962 - 1965 - 260 existing sheets on Northern part of Libya. 10 % of Libyan territory is covered. Each map corresponds to 1/16 of square degree (688 sq. Km.). Very poor quality.
- Provisory map at the scale of 1/5,000 from aero explorations, covering 3000Km2 in Cyrenaica. A total of 480 sheets, each of 6.25 square kilometers.

Old maps of no practical use

- 1/2,000,000 From the British Army - War period
- 1/500,000 " " " "
- 1/100,000 " " " "
- 1/400,000 From the Italians - Pre-war period
- 1/100,000 " " " "

Existing Aerial Photography

1 - Air Survey Company : 1/24,000 - 1953. A total of 2,500 photos. From 12° East to the longitude of Zliten, from the sea to maximum latitude of 32° N. These photos were seen in the geological section of the Ministry of Industry. A collection exists in the Ministry of Petroleum Affairs but unclassified.

2 - U.S. Army Mapping Survey : 1/30,000 - 1954. Northern part of Libya. These photos were seen in the geological section of the Ministry of Industry.

3 - Aero Explorations : 1/15,000 from Cyrenaica down to Isohyetal line 200 mm., seen in the N.A.S.A., Benghazi. Very important in Cyrenaica.

4 - Aero Explorations (working for A.L.L. Company) 1/15,000 and 1/6,000 only for towns and populated areas in Cyrenaica and desert to maximum latitude of Aouinet-Ouemin.

5 - E.I.R.A. (working for Doxsiadis) 1/15,000 and 1/5,000 only for towns and populated areas in Cyrenaica, from the coast to Kufra.

6 - E.I.R.A. 1/6,000 : Beida.

7 - E.I.R.A. 1/10,000 only for the coastal road (Tripoli-Benghazi).

8 - E.I.R.A. 1/2,500 only for air-fields.

9 - E.I.R.A. 1/15,000, 1/6,000 (working for Whitting Co.). Only for towns, oases and two valleys in Fezzan.

10 - E.I.R.A. (working for Whitting Co.). Tripoli area only : 1/4,000. Between the latitude of Aounet-Ouemin and the border.

11 - Ferey (working for Mac Gaushy Lucas Co.) 1/6,000 and 1/1,500. Only for towns and populated areas, from Homs to El Agheida.

Existing Air Photography but not available.

1 - 1/60,000 U.S. Army mapping survey covering at least the Northern part of Libya. A collection exists in the University of Tripoli, but unclassified. Perhaps available by special request to the U.S. Aerial Photo Service.

2 - 1/60,000, Jack Amman (working for oil companies) covering almost the whole Libya. Unseen - not available.

Availability of maps for pedological study

Small scale. There are two incomplete sets of maps at the scale of 1/250,000 and 1/50,000. They are U.S.A.M.S. maps made for the Libyan Government and could be obtained on a special request. In spite of their poor quality, they could be used for pedological study in the Northern part of Libya (Tripolitania and Cyrenaica). In Fezzan there is only a good Italian map, scale 1/1,000,000 dating from pre-war period. It is old and now out of print. It could be photographied or manually copied. Still it will be better to make a new map at the scale of 1/50,000.

Large scale. 1/5,000, 1/10,000.
Often there is no map, not even a cadastral map at such scale.
To study agricultural settlement when such map is needed, NASA is using hand made location plans.

Availability of Aerial Photos for pedological study

Many aerial photos have been taken in Libya, but almost none of the negatives are available, therefore it is impossible to obtain these photos when needed.

Consequently, the following existing maps could be used for pedological purposes :

small scale	U.S.A.M.S. 1/60,000 U.S.A.M.S. 1/30,000 (old)
Medium scale	Aero-exploration 1/15,000, available only for Cyrenaica and Fezzan. No complete coverage for Tripolitania.
Large scale	1/2,000, 1/4,000 and 1/6,000, available only for towns, air-fields and coastal road.

Pedological Survey requirements for aerial photos and maps
(according to special report on aerial photos and maps)

Aerial photos

Scale 1/40,000 in Tripolitania and Cyrenaica.

Scale 1/4,000 in Agricultural Settlement Project.

Maps

First priority - Fezzan valleys at a scale of 1/50,000 (or the old Italian map corrected and modernized).

- Agricultural Settlements, scale 1/5,000 and 1/10,000, according to the needs of the Ministry of Agriculture and the N.A.S.A.

Second priority - Complete and improve 1/50,000° map (actually poor quality).

Third priority - Map at the scale of 1/100,000, according to Southern border of Zone II of the joined maps.

- In Tripolitania, from seaside to 31° N. latitude approximatively.
- In Cyrenaica, from seaside to approximate line : Ajdabiyah - Al Makili and southwards from Tobruck.

CHAPTER IV

PRINCIPLES, OBJECTIVES AND SUCCESSIVE STAGES OF THE PEDOLOGICAL STUDY

1. OBJECTIVES :

A complete and well made pedological study must correspond to several objectives.

1.1. SCIENTIFIC OBJECTIVES :

The pedologist must always use the most recent data of the science of pedology, especially for analyses and classification. For analyses, his role is not to make them himself, this being the function of the chemist, but the pedologist indicates which analyses he desires and keeps himself informed of current techniques in order to judge if the results agree with what he observes in the field.

On the other hand, in the matter of soil classification, his role is irreplacable and very important. There is no question of himself making a classification, this function having evolved to a small number of famous professors. A certain number of competitive classifications exist, which are known world-wide. For the Mediterranean and dry countries, one can refer to the following classifications : American, Russian, French, Belgian, English, Portuguese. All these classifications have their advantages and their disadvantages, but they all show the influence of their authors and are especially well adapted to the countries where the authors have worked.

The English classification is in general very pragmatic, especially for the study of local problems without going further. This system is not easily adaptable because it is not a true classification. The Belgian and Portuguese classifications are especially fitted to the central and southern African countries. They are poorly fitted to the Mediterranean and arid countries.

Therefore, there remain the Russian, American and French classifications, of which the part adaptable to Libya have been made by the study of the soils of Central Asia (Russian classification),of North America (American classification), of Tunisia, Algeria, Sahara, Lebanon, Chad and Niger (French classification).

The Russian classification is presently in full evolution and is fairly confused. In a few years, this situation perhaps will have changed. Presently, it appears difficult to recommend it.

The American classification has the big advantage to be expressed in the English language. Its advantage is to be very logical, but it is undoubtedly a little rigid to be specially applied to arid soils (it is a morphological classification)

One of its inconveniences is the employment of odd words, such as Usdert, frangipan, ochric, which nobody understands without one or two months of work.

The French classification for the Mediterranean and arid countries has been sharpened in the countries which surround Libya and which have the same soils, and the same problems. It appears to us to be the best adapted to Libyan soils and will permit future comparisons with neighbouring countries.

In conclusion :

Two classifications can be utilized for Libya :
The American classification (seventh approximation),
The French classification, which appears the best adapted.

The Libyan Government experts must decide which of the two of the foreign companies must utilize. After the choice has been made, it is very important always to use the same classification.

1.2. PRACTICAL OBJECTIVES :

Although a pedological study must be scientific, it must not loose sight of practical problems and of the methods of solving them. Among the problems, one can mention :

- -The possibilities of irrigation, with or without necessary drainage,
- -The dangers of erosion now and in the future,
- -The factors that limit land reclamations, such as the depth of soil, the contents of mineral elements useful to plants, the salinity, the free lime, etc..
- -The types of recommended reclamation : orchard, irrigation, dry-farming, reforestation, etc..
- -The fertilizer needs,
- -The nature of complementary studies such as the adaptation of plants to irrigation by brackish water, the use of fertilizers, the amount of irrigation, and its periodicity applicable to the seasons and the soils, etc..

If the scientific study has been thoroughly made, these questions will be relatively easily answered.

The problem of land-capability classification is simpler than a pedological classification : nearly all pedologists are in accord to use their land capability, the American system of classes and subclasses, with symbols which indicate the work to be done : levelling, removing of stones, making of benches, reforestation, wind breaks, drainage ditches, etc...

1.3. INTERNATIONAL OBJECTIVES :

It is evident that in our epoch, countries are no longer isolated one from the other and that all are united in various international organizations (UNO, FAO, UNESCO). The role played by these organizations is far from being

negligible in assisting the countries which ask for it. But for a request for technical assistance in agricultural matter to be accepted, it is necessary for the report to be complete and, particularly, to include soil studies. Another role of these international organizations is to make inventories of world resources ; the pedological inventory is included to determine the extent and the possibilities of cultivable soils.

2. THREE KINDS OF PEDOLOGICAL STUDIES :

2.1. GENERAL SURVEY STUDIES:

These studies are made on the following scales : 1/250,000, 1/100,000, 1/50,000. They are a general inventory including in addition maps and reports ; they show the principal capabilities of soils and certain incapabilities mappable at these scales. Their object is to define a more precise program of pedological studies, and to establish the preliminary projects of land reclamation.

The general surveys give documents that are more scientific than practical. But the pedologist may be asked to give special study to problems such as, for example, the study of irrigatable land in desert or semi-desert areas, in order to create oasis where it is known that underground water exists in large quantities.

However, the object of a reconnaissance study is to outline - in the preliminary stage - the lands on which it will be necessary to make more detailed studies and those on which it is useless to work (rocks, salty land, etc..).

2.2. SEMI-DETAILED STUDIES :

These studies are made on scales of 1/20,000, 1/25,000 and 1/50,000, the last being more precise than in the case of the general study.

In another chapter, it is recommended that the 1/50,000 scale be used for the pedological study of the Jeffara, the Western Mountain, the zones of Tripoli and Misurata and the Green Mountain of Cyrenaica.

In effect, the fairly homogeneous soils of the Jeffara and the large extent of stony soils of the Tripolitanian and Cyrenaican mountains do not require, in a preliminary stage, great precision (which is not the case for the following stage). It is especially important to outline the zones that are useful for agriculture and those that are not.

The semi-detailed study always has a scientific character, but it must necessarily be much more practical than in the preceding case.

The report, the land capability map and the erosion map must particularly mention :

-The capability of dry-farming,

-The capability for irrigation, with an estimate of water resources, if possible, and especially of the limiting factors ; depth of soil and permeability. The presence of erosion or its future possibility, with its favoring factors : dip, wind, streams, etc.. and the method of remedying them,
-Cultural systems and the culture systems best adapted to the different soil units,
-Fertilizer needs,
-Necessary future experiments, especially for the amounts and frequencies of irrigation and the fertilizer needs.

The semi-detailed study is satisfactory when it is a case of dry-farming or of culture requiring little water (olive and almond trees), but the semi-detailed study is insufficient for irrigation and agricultural allotment. Therefore, this type of study cannot go further than a preliminary project.

2.3. DETAILED STUDIES :

Scales 1/15,000, 1/10,000 and 1/5,000.

The scales 1/10,000 and 1/5,000 are recommended because the 1/15,000 is an odd scale, but in Libya it will sometimes be necessary to use the 1/15,000 scale in places where no other base exists than photographic coverage at this scale.

This study, without neglecting the purely scientific aspects, must be essentially practical, and can be directly used by agronomists. Often, this study cannot be completed without discussions and consultation with other specialists (agronomists, irrigation specialists, etc..). In addition to the information given by the semi-detailed study, the detailed study must give the hydrodynamic characteristics of soils : speed of filtration, water capacity, useful water, dangers of salting of soils, if the irrigation water is brackish.

With the collaboration of irrigation specialists and agronomists, it will be possible to determine on the irrigatible zones the list of suitable cultures, the necessary fertilizers, the amount of irrigations and their frequency, and even the dimensions of water source tubes. This gives an idea of the precision demanded for such a study.

3. THE TWO STAGES OF A PEDOLOGICAL STUDY :

3.1. FIRST STAGE : GENERAL STUDY OR SEMI-DETAIL STUDY.

In all countries there are very good lands, others less good, and finally others that are bad. The object of this first stage is to divide the soils into different categories of which the cultural capabilities are the same. It allows the elimination, by relatively rapid work, of the zones that are less interesting for agriculture (stones and salty soils) and allows the classification of other zones according to their agricultural possibilities.

It is obvious that an argillaceous soil does not have the same properties as a sandy soil and that it is necessary to use differently a good firm soil and sands which move with the first gust of wind.

The small-scale (1/250,000) reconnaissance studies will be made in either the very badly known regions (which is not the case in Libya) or where the agricultural possibilities are poor (semi-desert or desert) but where lands of good quality can be found that are susceptible to irrigation of water if available.

The semi-detailed (1/50,000 to 1/20,000° scale) studies are applicable to zones where there is already an important agriculture that is to be improved and conducted to a modern stage. This is the case for the coastal fringe of Tripolitania and of Cyrenaica in Libya.

3.2. SECOND STAGE : DETAILED STUDIES.

These are made on large scale maps : they will be long and costly. Therefore, they should be undertaken only on the zones already well defined by reconnaissance and semi-detailed studies.

These studies give information useful for agricultural allotments, for irrigation, for the choosing of cultural systems, and for the promotion of modern agriculture with estimations of the related first expenses.

CHAPTER V

LOCATION OF PEDOLOGICAL STUDIES IN LIBYA

1. GENERAL PRINCIPLES AND USES

1.1. It is possible to undertake the pedological studies in two ways :
First : Watersheds, one by one. This method is very useful for precise purposes, but often blanks are left and they are lacking in the general survey when a recollection is made for establishing a general pedological cover.
Second : Topographic maps, one by one. This way is more suitable for a general survey because complete coverage is made at once.

It will be very easy to confine the two methods by undertaking a pedological study on the precise topographic sheets covering the catchment area to be improved.

1.2. A pedological study is only useful in the sites where rainfall and water supplies are available for dry and irrigated farming, grazing and forest husbandry.

If there are no water resources, soil, farming and grazing, pedology has only a general scientific purpose and can be made at a very small scale of 1/1,000,000 or 1/500,000; in fact, this study is unable to improve development in the country, except when it is possible to find water (i.e. by drilling wells), but that is the purpose of hydrogeology.

According to the isohyetal map of Libya (Fantoli, Magazzini), discussions with experts working in the country and information from reports and documents, the whole country is divided into three zones, as follows :

1.3. Zone 1
Dry farming area with possibilities for irrigation when a water supply is available.

This zone corresponds to an annual rainfall exceeding 150 mm. in Tripolitania and 300 mm. in Cyrenaica ; this difference is caused by the properties of the soil:- sandy in Tripolitania, clayed and loamy in Cyrenaica.

1.4. Zone II - Semi desert

This includes areas where there is only extensive grazing with very poor farming in the wadi valleys. A general soil survey, with an associated plant survey, is necessary for the following two purposes :

First: To delineate the best soil for grazing and possible farming if it is possible to find water by drilling.

Second : To estimate the value of various grazing areas and the number of cattle in order to avoid overgrazing. Three pedologists and one botanist (expert in phyto-ecology) in the same team should be necessary for a quick and complete study.

Of course, a phyto-ecological map will be added to the final documents. The only available basic map for this study is the U.S. topographical map at the scale of 1/250,000.

N.B. : In case of a new topographical map at the scale of 1/100,000, it would be more interesting to undertake these pedological and phyto-ecological studies at such scale, but net cost will be five times higher with poor benefit.

1.5. Zone III - Desert

The only important areas in the desert are the oases. The first work to be done should be a detailed study of the oases to improve the existing farming.

In the valleys between oases, it will be useful for the future to study the soil in order to delineate., in a general survey, the best soil where new wells could be drilled.

The only existing basic map for this study is the old Italian map at the scale of 1/100,000°.(this map is out of print).

N.B. : In case of new topographical map at the scale of 1/50,000, it would be more convenient to undertake pedological study with such map and at such scale.

2. AREAS WHERE PEDOLOGICAL STUDIES ARE NEEDED.

2.1. According to the last paragraph and the attached maps, it is possible to establish the following schedule :

Zone 1 - Dry farming areas with possibility of irrigation.

Tripolitania - about 25,000 sq. Km.

Geffara, Western Mountains, Misurata area, with an average annual rainfall of more than 150 mm.

The number of the corresponding 1/50,000 topographic U.S. map sheets are as follows :

N° 1691		II	III	
1690	~~I~~			
1790	I	II	~~III~~	IV
1890	I	II	III	IV
1990	I	II	III	IV
2090	I	II	III	IV
2190		II	III	
1889	I	II	~~III~~	~~IV~~
1989	I	II	III	IV
2089	I	~~II~~	~~III~~	IV
2189	I	~~II~~	~~III~~	IV
2289	I	~~II~~	~~III~~	IV
2389	I	II	III	IV
1588	~~I~~			
1788	~~I~~			~~IV~~
1388	~~I~~			~~IV~~
1988	~~I~~			~~IV~~
1688	~~I~~			~~IV~~

III Pedological work will be done on the entire sheet.

~~III~~ Pedological work will be limited to part of the sheet.

Cyrenaica - About 8,800 sq. Km.

The Green Mountain and the coastal belt with an annual rainfall of over 300 mm., and the area around Benghazi where there are many wells. The number of the corresponding 1/50,000 U.S. topographical map sheets are :

N° 3490	I	II	III	
3590	I	II	III	IV
3990	I	II	III	IV
3790	I	II	III	IV
3890		~~II~~	III	IV
3389	I	II	III	IV
3489	I	~~II~~	III	IV
3589	I		~~III~~	IV
3689	I			IV
3789	I			~~IV~~
3889	I	~~II~~	III	IV
3488				IV
2288	I	II		

IV Pedological work will be done on the entire sheet.

~~IV~~ Pedological work will be limited to part of the sheet.

First step : pedological study and mapping at a scale of 1/50,000 (the only available topographic map).

Second step : in the best areas with boundaries previously delineated in the first step, pedological study and mapping at a scale of 1/15,000 (+), 1/10,000, 1/5,000, according to existing topographic maps, aerial photos or photo-plans.

(+) 1/15,000 is an odd scale recorded here for it is the only scale of certain aerial photos existing in Libya.

2.2. Zone II - Semi-desert, Extensive Grazing Areas.

Tripolitania - About 55,000 sq. Km.

Areas included between isohyets 150 mm. and 50-100 mm. ; catchment areas of wadi al Mardun and wadi Sawfragin, where during Roman times there was prosperous agricultural husbandry.

The numbers of the corresponding 1/250,000 U.S. topographical maps are :

NI-32	~~16~~		
NI-33	~~13~~		
NH-32	4		
NH-33	1	2	~~3~~

(4 work will be done on the entire sheet)

(~~13~~ work will be limited to part of the sheet)

Cyrenaica - About 27,000 sq. Km.

Areas included between isohyets 300 mm. and 50-100 mm. ; some basins of wadis , i.g. wadi el Gabr, wadi as Shabrag. The number of the corresponding 1/250,000 U.S. topographical map sheets are :

NH-34	2	~~3~~	~~4~~	~~6~~
NH-35	1			
NI-34	~~16~~			

(1 work will be done on the entire sheet)

(~~16~~ work will be limited to part of the sheet)

First step : study and mapping of these areas at the scale of 1/250,000 with combined pedological and phyto-ecological surveys. These areas have not much interest for agricultural purposes due to the lack of water, and are now used for extensive grazing.

Second step : where underground water does exist (see hydrogeological survey) and in the oases (Nalut, Mizdah, Ben-Ulid, ...), it would be important to make a map at a larger scale - 1/5,000, 1/10,000 and 1/15,000 according to the basic topographic documents existing in the way of maps, aerial photographs and photoplans.

N.B. : 1/15,000° is an unusual scale.

2.3. Zone III - Fezzan, Ghadames, Ghat, etc.

First step : Oases

In the desert, the only important areas right now are the oases.

Study and mapping at the largest possible scale, 1/5,000, 1/10,000 and 1/15,000, according to existing basic maps and aerial photos.

Second step : Fezzan - Valleys.

Study and mapping at a scale of 1/100,000° ; this old Italian map is the only existing map. It is not available but could be photographed or copied.

It would be advisable to make a pedological study from topographic map at the scale of 1/50,000, should this be established.

3. SPECIAL CASE - AREAS WHERE SOME SOIL SURVEY WAS ALREADY DONE BY PRIVATE FIRMS.

3.1. These surveys cover an area of about 5,300 sq. Km. in Tripolitania and about 3,500 sq. Km. in Cyrenaica, with land capability map (Tripolitania) and land use map (Cyrenaica). True pedological study and maps were never done.

It will be important in the future to obtain the above mentioned documents.

3.2. First solution :

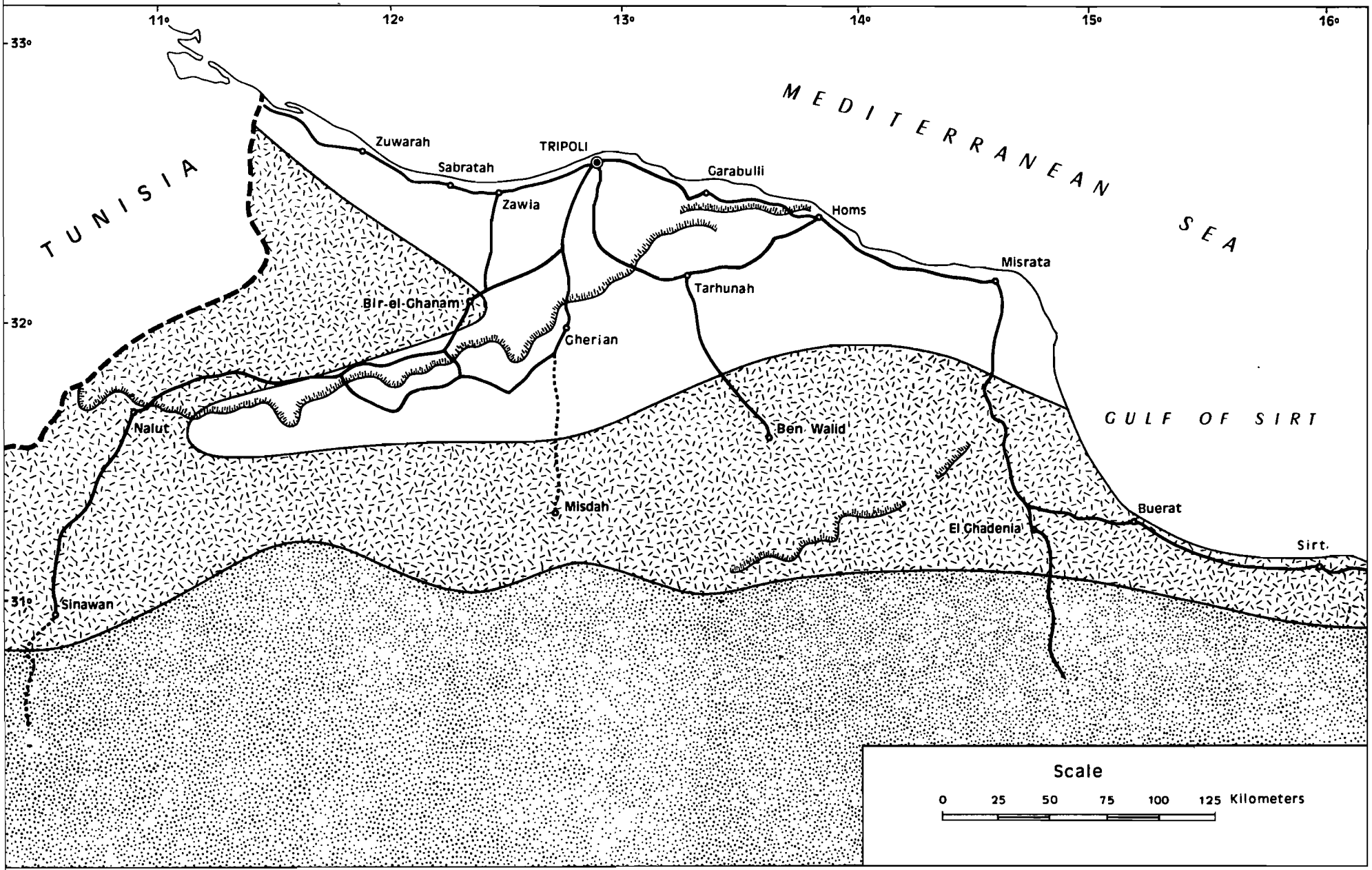
Requesting foreign companies to complete their work. This could be done by means of rider to the previously completed contract.

Second solution :

Do the pedological studies as if nothing had been done before.

3.3. The first solution will be less expensive than the second (about half the price) but the second will be better for obtaining homogeneous information and documents.

SOIL SURVEY PROGRAMM IN TRIPOLITANIA

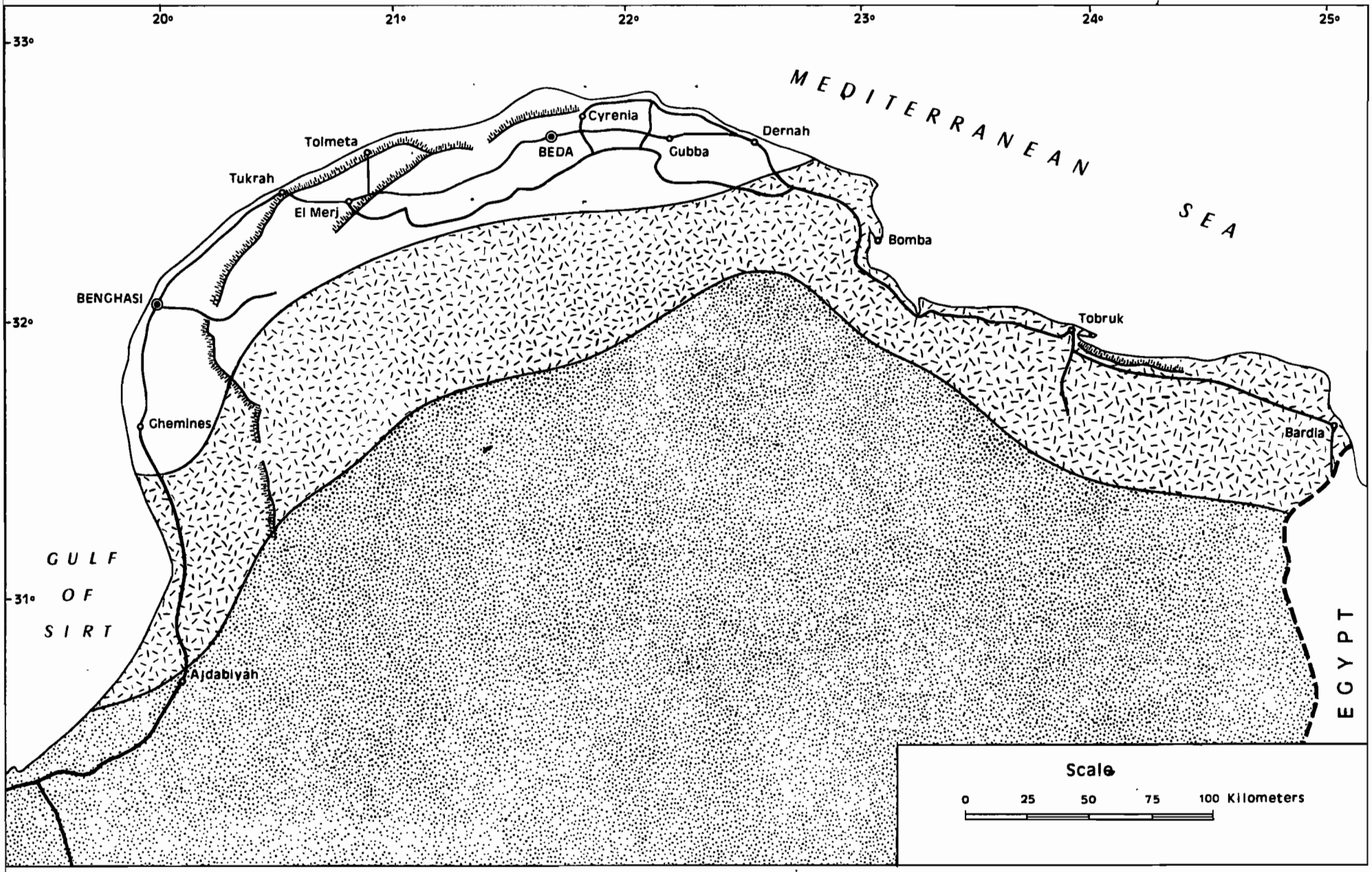


Zone I - Dry-farming + irrigation
Pedological study at 1/50.000

Zone II - Semi-désert extensive grazing
Pedological and phytoecological study at 1/250.000

Zone III - Desert Pedological
study only in oasis areas

SOIL SURVEY PROGRAMM IN CYRENAICA



Zone I - Dry-farming + irrigation
Pedological study at 1/50.000

Zone II - Semi-desert extensive grazing
Pedological and phytoecological study at 1/250.000

Zone III - Desert Pedological
study only in oasis areas

4. SUMMARY

Zone	Rainfall	Agricultural Husbandry	Location	Scale
Tripolitania and Fezzan				
I Coastal belt	Average annual rainfall more than 150 mm.	Dry-farming and irrigation	Geffara Western Mount. Misurata area	First step : 1/50,000 Second step : 1/5,000 to 1/15,000
II Half desert	Average annual rainfall between 150 mm and 50-100 mm.	Extensive Grazing	Western Geffara and Southern part of Western Mountains	First step : 1/250,000 or 1/100,000 Second step (oases and valleys) 1/5,000 to 1/15,000
III Desert	Average annual rainfall less than 50-100 mm.	Nothing except in the cases	Fezzan and other oases	First step : cases 1/5,000 to 1/15,000 Second step : Fezzan valleys
Cyrenaica				
I Coastal belt Green Mountains	Average annual rainfall more than 300 mm.	Dry-farming and irrigation	Coastal belt and Green Mountains from Benghazi to Derna	First step : 1/50,000 Second step: 1/5,000 to 1/15,000
II Half desert	Average annual rainfall between 300 mm and 50-100 mm.	Extensive Grazing	Areas south of the Green Mountains as far as 75 - 100 km.	First step : 1/250,000 Second step : oases and valleys 1/5,000 to 1/15,000
III Desert	Average annual rainfall less than 50-100 mm.	Nothing except in the oases	Kufra and several small oases	Oases : 1/5,000 to 1/15,000.

CHAPTER VI

P R I O R I T I E S

All the pedological studies cannot be undertaken and achieved at the same time.

The above surveying and its execution will last for a long time, (accepted practice and experience are well acknowledged in other countries). In the first stage attention should be focused on some regions which have a special importance for agricultural development.

Special conditions of pedological work should include the two steps described below :

First step : Studying and mapping at the scale of 1/50,000 (Zone I) and 1/250,000 (Zone II).

Second step : Mapping and studying, according to the requirements of the Ministry of Agriculture and the National Agricultural Settlement Authority (NASA), the areas available for agricultural purposes previously delineated in the first step.
Scale 1/5,000 and 1/10,000.

The second step should be undertaken after the first step.

Following the nation's development policy and bearing in mind the special importance of some regions for agricultural development in Libya, priority importance should be given to :

Western Region

Geffara region, entire Tripoli, Zavia and Garabuli areas. Misurata and West Mountains district should be embraced paralelly as follows :

First priority : Existing and future irrigated areas ; wadi cultivation.
Second priority : Entire dry-farming zone over 150 mm. of rainfall, according to Zone I on attached map.
Third priority : Semi-arid zone (chiefly extensive grazing) ; these areas are included between the isohyets 150 mm. and 50-100 mm. according to Zone II on attached map.

Eastern Section

Green Mountain region, Derna district and Benghazi area, areas from the Green Mountain to the isohyet 50-100 mm.

First priority : Irrigated area, wadi culture area, agricultural settlements.
Second priority : Entire dry-farming zone with annual rainfall of over 300 mm.
Third priority : Semi-arid zone (chiefly extensive grazing), these areas are included between isohyets 300 mm. and 50-100 mm., according to Zone II on attached map.

Southern Section

Southern desertic region including the entire Sebha and Ubari areas with all their oases ; Kufra oases.

First priority : Scale 1/5,000 and 1/10,000.
Oases at the border of the country (Gadames, Ghat, Auenat, etc.)
Ministry of Agriculture projects : Traghem, Brack, Sesha.
NASA projects.
Second priority : All the other oases.
Third priority : Fezzan valleys, studying and mapping at the scale of 1/100,000 or 1/50,000 according to the existing topographic cover.

These priorities are established according to the document entitled "Basic requirement of long term investigations of the natural resources of the Kingdom of Libya", Ministry of Agriculture and NASA projects, and discussion with experts.

But it is evident that such list of priorities will very soon be out of date. Consequently, the experts of the Government will have to make modifications in the above mentioned list and even in the general work programme as and when the conditions of the country make this change necessary.

C H A P T E R VII

Members in Pedological team and work possibility in Libya

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1 - Preface.

These following informations are only given to guide Libyan government in order to have an accurate point of view about this problem.

Although experienced pedologists have often their own methods to perform pedological studies, and it is generally better to allow them some latitude in forming their teams.

For foreign companies working under Libyan contract, the best way is to give them liberty and send to Libya the number of employees who are familiar with their work and can make their surveying teams in their own way.

2 - Various kinds of specialists included in Pedological team and their part.

2.I.- Surveyor-pedologist.

This person shall be scientist of a higher rank (Doctor of Science or at least Philosopher Doctor in American system ; University or Superior Agronomy School graduate with two years of special pedological study in French system) at least ten years of experience in pedological field.

His duty is to guide younger pedologists, to give them information and orders, in dividing job, controlling work done, visiting main profiles and checking analyses.

A good surveyor should have sufficient knowledge in modern soil classifications and should be able to discern possible gaps in these classifications.

He must have good knowledge about agricultural capabilities of arid soils.

He should have information regarding modern analysing methods and their possibilities.

In pedological study, the proper number of surveyors should be from one to three (or four) pedologists (or technicians).

2.2.- Pedologist.

The same level of study is requested for pedologist.

He should have at least three or four years ef experience in soil survey work.

He should be able to work on his own manage and guide technicians and assistants.

His duty is chiefly on the site visiting pits, describing profiles, taking samples, writing reports and conclusions under the control of his surveyor when he is incorporated in a team.

It is often advisable that every pedologist applies his own hands in some chemical and physical analyses from his soil samples in order to know possibilities and limits of analysing methods.

2.3.- Technician.

This technician can be a young pedologist making his first steps or an experienced agent (High School education) specialised in pedological work.

A technician should do his work in the fields, examining profiles, taking samples, but under the supervision of an experienced pedologist.

2.4.- Assistant.

His duty is to help pedologist and technician for secondary tasks : supervising labourers, digging pits and bored holes with labourers, filing samples and collecting data from soils boundaries.

Often these assistants are locally recruited by foreign companies.

2.5.- Labourers.

For digging holes and pits. Variety in number according to local situation.

3 - Material - Vehicles.

There are only few materials used by pedologist : showels, picks, hand-drills, compasses, maps, sample-sacks, pails, etc ...

A car takes almost important part in work, preferably front-wheel drive car.

It is necessary that every surveyor pedologist, technician and assistant would be in possession of his own car. Front-wheel drive car is absolutely necessary to the assistants in transporting workers and materials.

Often, small cars (different kinds are made in England, France and Germany) can be used by surveyors, pedologists and technicians. They are three times less expensive than front-wheel drive cars (purchase and maintenance) and are almost as useful as the former for work on the site.

4 - Average area covered by different Pedological Teams per year.

Scale	Type	Team	Average area covered per year
1/250,000	Pedology Phytoecology General survey	3 pedologists 1 botanist 4 labourers	about 15,000sq-Km
1/100,000	Pedology - Phytoecology General survey	3 pedologists 1 botanist 3 assistants labourers	about 4,000sq-Km
1/100,000	Pedology General survey	A First system 1 pedologist 1 assistant labourers	700sq-Km
		B Second system 1 pedologist 1 technician 2 assistants labourers	1,000 to 1,500 sq-Km
1/50,000	Pedology Semi-detailed survey	A First system 1 pedologist 1 assistant labourers	250* to 300 sq-Km
		B Second system 1 surveyor 3 pedologists 3 assistants labourers	600* to 750 sq-Km
1/25,000	Pedology Semi-detailed survey	A First system 1 pedologist 1 assistant labourers	80* sq-Km
		B Second system 1 surveyor 3 pedologists 3 assistants labourers	240* sq-Km

Scale	Type	Team	Average area covered per year
1/I5,000	Pedology	A First system	
	Detailed survey	1 pedologist 1 assistant	40 sq-km**
		B Second system	
		1 pedologist 1 technician 2 assistants	80 sq-km
1/I0,000	Pedology	A. First system	
	Detailed survey	1 pedologist 1 assistant labourers	20 sq-km**
		B Second system	
		1 pedologist 2 technicians 3 assistants labourers	40** to 50 sq-km
1/5,000	Pedology	A First system	
	Detailed survey	1 pedologist 1 assistant labourers	I0 to I5** sq-km
		B Second system	
		1 pedologist 2 technicians labourers	30** sq-km

(* these areas may be greater in zones where there are many rocky soils)
(** numbers quoted for detailed surveys (1/I5,000, 1/I0,000, 1/5,000) are very changeable according to the precision rate requested.

When surveyor is not quoted in composition of a team, surveyors must be included at the rate of one surveyor per 3 teams in second system, one per 4 teams in first system.

These kinds of team are commonly employed in pedological works, but there are other kinds; often it is advisable to give some latitude to the team manager in forming his own teams, according to special conditions on the ground and his own experience.

5 - Basic scientifical staff needed for long term investigations in five years plan.

5.I. General and semi detailed survey.

	Scale	Area in Km^2	Surveyor	Scientist per year
Zone 1				
Tripolitania	1/50,000	25,000	4	I3 Pedologists
Cyrenaïca	1/50,000	8,800	1 to 2	5 Pedologists
Zone 2				
Tripolitania*	1/25,000	55,000	1	4 Pedologists
			-	2 Botanists
Cyrenaïca*	1/250,000	27,000		2 Pedologists
				1 Botanist
Zone 3				
Fezzan Valleys	1/50,000	8,000	1	3 Pedologists
		TOTAL	7	3I Scientists

* Several Pedologists, with experience in arid regions, do not agree to make pedo-phytoecological map at the scale of 1/I00,000 as requested by some experts in Tripoli.

Such work should be very expensive with very poor results.

It should be more advisable to ask the pedologist to take a greater care regarding valleys (with flooded dry-farming cultivation) and good soils where irrigation is possible (available underground water, if it is existing).

In case the Governement of Libya decides to make this study at such scale (1/I0,000e), the number of requested scientists will be multiplied by five for that sort of study.

C H A P T E R VIII

SURVEYING THE FULFILMENT OF CONTRACTS AND PLANNING PEDOLOGICAL STUDIES

When a contract is established for any kind of study between government od Libya and one company, it is always most advisable to verify fulfilment of the contract on the spot and to estimate the scientifical and practical value of final documents resulting from study.

Finaly it is necessary to draw conclusions and consequences of the above mentioned study and recommend, according to aims of government of Libya, certain kinds of land improvement with subsequent complementary studies.

1 - Testing fulfilment of the contract by an inspector.

1-1. The inspector should be selected by competent Libyan authority to be in charge for very important matter.

This inspector must be qualified pedologist having experience in work on the ground, able to estimate complicated conditions under the study and verify if duties are performed in a right way by the contractor. He is the middle party between contractor and libyan government.

1-2. The first duty of the inspector is to verify fulfilment of the contract.

He will mainly control :

- that the contractor follows special clauses mentioned in the contract and he uses particular methods of pedologists in that sort of work.
- that the contractor does not commit serious breaches in observing articles aims and purposes of the contract. In case of breaches, he shall determine if these breaches are justified by some special conditions on the site.
- that the contractor does not commit any serious technical error and do not use bibliographical data as a substitute for his proper work.

The inspector shall verify the advancement of the work in examining rough soil map and drafts with their daily entries and checking pits and analyses.

It is necessary that such control takes place at regular times (three months appear as available interval) and every time as an advance payment is requested by the contractor.

In case of delay, the inspector must estimate if this delay is caused under special condition on the spot impossible to foresee in the contract or under events beyond any control of the contractor.

I-3. the second duty of the inspector is to help the contractor in certain tasks. He shall have to meet the contractor and his responsible pedologists to make clear some possible interpretations of the contract on his own request or on the request of the contractor.

He will give to the contractor, at the office and on the spot, information regarding soil classification principles, soil genesis and possible land use in order to obtain a coordination as great as possible in different pedological studies over the whole Libya.

In general he shall give advices and opinions to scientists on the spot either informally or in writing.

1-4. the third duty of the inspector is to give advices to Libyan Government in order to complete and precise the study for supplementary analyses and works.

Depending on the special conditions of the site, it may be necessary for the contractor in some places (where soil units are very imbricated or boundaries very difficult to delineate), to make supplementary pits, auger-holes and subsequent analyses. The inspector shall attach his own opinion, favourable or unfavourable, to any application of the contractor for that kind of job, and shall make clear to the responsible administration what are useful and useless works.

For soil analyses, certain of them are to be made only on some samples in order to characterise entirely one or several soil units or to answer problems encountered during the course of the study (these analyses are mentioned in Annex III of tender documents under the Class Four). The contractor should make applications for that supplementary analyses but the inspector must attach his own opinion favourable or unfavourable in order to inform responsible administration regarding these analyses Class Four and to avoid unnecessary expenses.

In general the inspector should give his own opinion concerning every addition or change in the contract.

2 - Estimating value of final documents submitted by the contractor.

2.I. The scientifical and practical value of every document submited to Government of Libya by contractor should be checked by a committee of top experts composed as follows :

- pedologist at least ten years experienced in soil genesis and classification with a good knowledge of work on the field.
- agronomist or pedologist at least ten years experienced in problems of soil conservation and land reclamation.
- soil chemist at least ten years experienced in soil chemistry.
- soil physicist at least ten years experienced in soil physics and very acquainted in water-soil relationship.

2.2. The duty of that committee is to estimate the value of documents resulting of pedological studies from two points of view : at first, in a scientifical point of view, in order to verify if methods used and analytical data obtained are correct and convenient, if pedological, land capability and erosion maps are made as usual in pedological way, and if results and conclusions are true regarding local conditions.

Second, in a practical point of view, in order to estimate if recommendations made by contractor concerning land reclamation, land improvement, new crops, irrigation projects, soil conservation are correct and easily utilizable in agricultural grazing and forest practices according to special conditions of Libya.

2.3. After these two examinations, the committee should make recommendations to Libyan government regarding :
- scientifical and practical value of studies made by contractor
- compatibility with aim and purpose of Government of Libya
- practical applications resulting from these studies
- necessity of other studies on complementary points.

3 - Planning soil studies.

3.1. However a plan and priorities in pedological studies be given in general lines in this report, it is obvious that this plan and those priorities will be very soon outdated. It will therefore ensue that the experts of the Government will have to make modifications to mentioned priorities and even to the general work program as and when the conditions of the country make it necessary.

It is also to be noticed that for each region where a pedological study has been carried out, such study will bring to light new problems, - agronomic, pedological, erosion, irrigation problems, etc ...-, which will then have to be studied, principally by the agronomic stations : - Libya has 20 agronomic research stations which should be ample.

It will, however, be necessary to make a selection of such problems - they could not be studied at the same time - and draw up a work programm and supervise its execution.

3.2. For these works, it appears to be necessary to include in the Board of Scientifical experts a pedological team of top experts (including one or several experts quoted in paragraph 2-1) composed as follows:

pedologist
agronomist
soil chemist
soil physicist
economist
ecologist
etc .....

These top experts would be in charge of :

- planning pedological studies
- adjusting priorities to aims of Government of Libya
- drawing practical conclusions and consequences from soil studies
- establishing programm for new studies regarding problems brought to light by first pedological studies
- recommending some kinds of agricultural and grazing practices in areas already studied.

C H A P T E R IX

SUMMARIZED STATEMENT OF SPECIFICATIONS FOR TENDER DOCUMENTS.

The following specifications are for the purpose of facilitating interpretation of tender. They are mainly concerning technical part relevant to the working conditions which is quoted in tender document as technical section.

I - EXPLANATORY STATEMENT.-

The Administration will indicate :

- the type of study to be undertaken (pedological)
- the other studies to be undertaken at the same time : hydrology, hydrogeology, botanic, agricultural experiments.
- aims to be attained : dry-farming, irrigation, agricultural allotments, pasturage, refosteration, etc .....

It is necessar to include this information concerning the other studies as it can be of great importance on the pedological side; the same applies to the construction of a dam which will influence - in one way or the other - the alimentation of the phreatic level, whose effect on the irrigation and drainage should be foreseen.

A reforestation programme can change the course of the flow and so change the pedological conclusions in the future.

II - OBJECT OF THE AGREEMENT.-

It is necessary to define more precisely than heretofore the type and, above all, the scale of the study envisaged.

In pedology, there are 3 types of study :

2.I. General Surveys (on a small scale)

These are primarily useful to define the areas of interest for agriculture and in order to have a good idea of the possibilities of the area. This general survey must be undertaken on the following scales : 1/500,000; 1/250,000; 1/200,000; 1/I00,000; I/80,000; 1/50,000.

2.2. Half-detailed studies (on a medium scale)

The scale ranges from 1/20,000 to 1/50,000. They are often sufficient for Dry farming and for all instances where the irrigation is not being used systematically.

Note should be made that the scale 1/50,000 is an intermediate one and comes between the General Survey and the half-detailed study : not only does it allow for the demarcation of the areas suitable for agriculture before making the precisely defined study, but it is usually adequate to make a primary assessment (dry-farming, plantation of almond-trees, olive-trees, etc ...).

2.3. Detailed study (on a large scale).

Scale 1/I5,000, 1/I0,000, 1/5,000 according to topographic documents available. Such studies are absolutely indispensable for any very precise project, such as for irrigation, agricultural settlement, a change in the cultural system (system of cultivation). Naturally, these detailed studies take a long time and are very costly and should therefore only be made in the areas which the general or half-detailed studies have shown to be favourable.

If these studies have not been made before, it will be necessary to make a General Survey at 1/50,000 rather rapidly which will serve to indicate the areas to be studied in detail.

III - DEMARCATION OF THE BOUNDARIES.-

The demarcation is made preferably on a map on the same scale as that requested for the study. The 2 parties (Administration and Contractor) must be in agreement on the designing of the boundaries and the total surface to be studied. The overprintings, made in 2 copies on a topographic map, will serve as reference in any future dispute.

For studies made at scales ranging from 1/50,000 to 1/250,000, a total surface can be taken without subdivisions (watershed or complete map).

For detailed studies, the areas which the contractor must work on must be defined very precisely, making use of the studies already made (General Survey or half-detailed). If not, there is a risk of spending a lot of money on land which has no agricultural value.

IV - GENERAL LINES OF THE PEDOLOGICAL STUDIES.-

4.I. Practical Objective.

A pedological study should have as its objective the localising of the different units of soil, as well as their aptitude for irrigation and drainage purposes, their possibilities for cultivation, the dangers due to erosion, the necessity to use mineral and organic fertilisers, the work to be done. In order to establish the land capability map, the pedologist should use the American classification for indexing the soil. As it is not possible to foresee everything in advance, and certain new problems will certainly arise during the course of the study, the contractor should make such problems known in his report, even if they are not actually mentioned in the contract (for example, the progressive augmentation of salinity of the soil on account of bad use made of the irrigation water).

4.2. Scientific Objective.

It must be borne in mind that a work undertaken with an immediate practical view in mind cannot make allowance for possible future problems. This is a difficult question which is difficult to prepare for.

On account of this, it is necessary to carry out the work as scientifically as possible : study of the vegetation, of the climate, of the geology, etc ... Above all, the contractor should be completely "au fait" with all modern methods used for pedology where analysis and classification of soil are concerned.

This last point does give rise to a certain confusion due to the existence of several types of classification methods. Each of these methods - American, Belgian, English, French, Portuguese, Russian - has its qualities and its faults; but, above all, they each carry the mark of the "scientists" whose method is principally based on the country where he has worked. (Portugal and South Africa for the Portuguese type of classification - European Russia and central Asia for the Russian classification, etc ...). It is therefore necessary to make a choice in recognition of this and to request the contractors to follow such choice.

Because of the geographical and climatic similarities, and because of the presence of the same type of soils and, moreover, of the same problems, it would appear highly preferable to adopt in Libya the classification used by pedologists in Algeria, Morocco and Tunisia : that is the French method of classification (slightly modified) which has been adapted in the North African countries (see Annexe IV f tender documents).

This method of classification is divided as follows : (Annex IV-A and Annex IV-B).

Soil Division
Soil Subdivisions
Soil Groups
Soil sub-groups
Family
Series
Type
Phase

The general survey maps and the half-detailed maps mention the class, group, sub-group and family (if it is possible); often, at a scale of 1/50,000, it will be possible to go as far as the "series" with indications of texture as well.

Where detailed maps are concerned, they should mention the sub-groups, the family, the series, the types found where texture is concerned, and the phases in order to indicate their influence of erosion (even weak) of the cultivation and vegetation, etc ...

V - PLAN OF PEDOLOGICAL STUDY.-

5.I. Examination of existing documents.- - geographical, geological, geomorphological, agronomical, botanical and also pedological if such exist; the contractor should present a complete list of such in the form of a bibliography and quote them in his report in order to indicate the origin of the information collected. Such a work might take a month or two, may be more dependant on the complexity of the region and the number of documents examined. However, in no case should any copy - whether completely or only partially - be used to substitute, even partially, the study requested under the contract.

5.2. Study of Aerial Photographs.- is equally essential for easing the work on site and for making it more precise. It is of course necessary to make use of aerial photos at a scale equal to, or greater than, that required in the final documents.

For the detailed studies where topographic maps on a large scale are often not available, a photoplan can replace these and give the agronomists in charge of the evaluation a plan of what is usable on the site.

In this latter case, the scale of the aerial photos will determine the scale of the study : with a photoplan at 1/15,000 only a pedological map and of the soil utilisation at 1/15,000 can be established, a scale sufficient for the agronomists but often not sufficient for the cadastral experts and the agricultural settlements.

5.3. Preliminary study of the natural conditions. It is advisable for the contractor to have as broad a view as possible of the agronomical and pedological problems of the whole region, and not only of the area to be studied. A rapid preliminary study should therefore be foreseen which give a general outline of the boundaries of the area which comes under the contract. This should take about two weeks and, in any case, should not exceed one month.

5.4. The prospection of the site naturally forms an important part of the work.

The pedologist will have to define the different units of soil found and state precisely in each profile and each horizon of the profile :

Colour (with the Munsell colour chart - American)
Thickness of the horizons in centimeters
Structure
Texture (tactile appreciation)
Permeability (rough evaluation)
Presence of pebbles, crust, salt, water ...
Presence of roots

and any other information which could be considered useful.

Moreover, for each profile, it is necessary to note the site, the inclination, the vegetation, the geology (in summary).

Finally, it will be necessary to indicate its place in the classification and its cultivable aptitude.

A sample of the soil index card is given in Annexe II.

The prospection of the site forms the longest part of the work. It is generally considered that a pedologist can study per year, office work included, areas indicated on the following table :

I/250,000	about	5000	square	kilometers
I/I00,000	"	700	"	"
I/50,000	"	250	"	"
I/I0,000	"	20	"	"
1/5,000	"	I0	"	"

The corresponding time required for the work on site would be 5 to 7 monthes.

5.5. Analysis of the soil.- The soil analyses should determine very precisely the chemical and physical properties of the soils. In Annexe III the methods considered best adapted to the Mediterranean soil and to $\frac{1}{4}$ arid soil are set forward, (See Second Part, Annexes of tender documents).

However, the chemistry of the soils is a difficult science which is contantly changing; it is possible that in the near future certain of the methods presently being used will become outdated; this is the reason for allowing the contractor a certain amount of freedom on condition that he indicates his reasons and submits a complete list of references on the methods used.

It is also possible that the agronomists put in charge of evaluating the area under study would need new analysis (trace-elements in particular); this is why it is desirable to request the contractor to file and keep his samples during a certain period of time.

The question of the trace elements is a very delicate one; some thirty trace elements are important, and in order to determine these in the most precise manner, a statistic basis should be used, from which a considerable number of analysis will result and at considerable expense.

It will therefore be most effective to make the occasional determination of trace elements (on 1 profile in 50, for instance); if a malady or a decrease in the yield appear in the cultures during the following years, the analyses of trace-elements in the soil and on the leaves of the plants will have to be combined.

All these chemical and physical analyses take an extremely long time and can be extended over a period of 3 - 5 months after the prospection of the site has been finished. Such time limits should be precisely agreed upon between the Administration and the Contractor.

5.6. The preparation of the final reports and the maps is usually usually made at the contractor's own company premises.

In particular, the finalisation of the maps can take a long time.

It is therefore quite normal for an interval of 5 - 6 months to elapse between the termination of the work on si e and the handing over of the final documents.Such time lapse should be agreed between both parties at the time of signing the contract.

5.7. Number of copies - the number of copies has to be fixed between the two parties. I5 is generally considered a minimum but it is more advisable to count on 500 copies according to need (see details in paragraph 9-9.

VI - STATEMENT OF THE OBSERVATIONS MADE.- A pedological study should always be made with a certain degree of précision : such précision is divided into 3 sections :

6.I. Precision of the boundaries of each unit of soil

Scale	Precision of the boundaries	
	1 - Good	2 - Fairly good
1/250,000	2 km	4 km
1/I00,000	500 m	800 m
1/50,000	250 m	400 m
1/I0,000	50 m	100 m
1/5,000	20-50 m	100 m

In general surveys and half-detailed studies (I/250,000, 1/I00,000, 1/50,000), the precision No. 2 is often usually enough but at a scale of 1/50,000, the precision No 1 will be necessary in certain cases. For instance boundaries of the saline soils, demarcation of units of soil having very different aptitudes (sandy soil and clay soils, rocks and good earth). In detailed studies, the precision No. 1 is necesaary to determine the boundaries of the good soils, for irrigation, special cultivation (orange tree, olive tree and vines, etc ...) and agricultural settlement. When it is a question of the cultivation of plants which can be grown in a large variety of soils (corn and barley in dry-farming), the Precision No. 2 is adequate.

N.B. This statement of the boundaries should be understood by the contractor to indicate a margin of maximum error and should never be exceeded. In fact the average amount of error should be less than the figures quoted above.

6.2. Useful characteristics of the different horizons. The characteristics concern all the soils; but for general surveys and half-detailed studies, it is not necessary to estimate their variations very precisely. On the contrary, such estimation is necessary in detailed studies in order to determine hydrodynamic characteristics - particularly in an irrigation project.

For every unit of soil, the contractor should indicate soil moisture equivalent, available moisture, permeability having an average value of ... , with a variation of ... in the same unit of soil.

If the variability exceeds 60% of the average, efforts to make subdivisions in the units of soil should be made.

6.3. Degree of Uniformity . If within the boundaries of one unit of soil A, there existe 80 profiles having the characteristics of soil A, and 20 others having certain characteristics of the neighbouring units B, C, D, it is ascertained that the unit of soil is 80% uniform.

The degree of uniformity which can be requested from contracting firms varies according to the scale.

Scale	Degree of uniformity
1/250,000	30 - 40%
1/100,000	50%
1/50,000	70 - 80%
1/10,000 and 1/5,000	85% - wheat, barley meadow 95% - irrigation, orchards, vegetables

VII - NUMBER OF OBSERVATION POINTS ON THE AREA UNDER STUDY.-

7.1. One calls "observation points" all the profiles of soil which the pedologist can find on the site.

- pedological trenches and pits
- bored holes and shovelled ones
- natural cuts.

Trenches at a depth of 1.80m - 2.00m represent the ideal for a pedological prospection, but this is also a long and expensive method of working. In fact in detailed studies, one can reduce the number of trenches and replace them by bored holes.

NUMBER OF OBSERVATION POINTS

Scale	1 - Maximum Very imbricated soils Boundaries delineating	2 - Good Rather imbricated soils	3 - Minimum Homogeneous areas
1/250,000	1 per 500 ha	1 per 1000 ha	1 per 2000 ha
1/100,000	1 per 25 ha	1 per 60 he	1 per 200 ha
1/50,000	1 per 10 ha	1 per 25 ha	1 per 80 ha
1/15,000	1 per 1 ha	1 per 3 ha	1 per 6 ha
1/10,000	1 per 0,50 ha	1 per 2 ha	1 per 4 ha
1/5,000	1 per 0,25 ha	1 per 1 ha	1 per 2 ha

These figures correspond to cultivable ground : naturally, for rocks, very salty soils, sand dunes, the minimum (3) is too exagerated. The first column is for imbricated soils and the soil boundaries. The second column for zones of only average imbrication. The third column is for the large surfaces of homogenous soil, frequently found in Libya. (The examination of aerial photos is very useful for choosing the number of suitable holes).

The 3 qualities as shown under 1, 2 and 3 can of course be used simultaneously for the same unit of soil and in the same study, according to the difficulties found on the site.

The number of trenches at 1.80 m to 2.00 m depth should number at least a minimum of 25% of the total observation points for the general survey or the half-detailed studies.

In the studies at a large scale, very detailed, (I/5,000, 1/I0,000), one can make a number of trenches (never less than 1 for 20 observation points) and verify by the numerous bored holes that the soil does not vary between the trenches. If a change is observed, it is necessary to make a new trench.

In pebbled soils, where it cannot be bored, trenches only should be dug (Cyrenaican coastal plain).

The pedologist's own experience, together with the help of the aerial photographs, will usually indicate to him the number and type of observations necessary.

7.2. Number of sampled and analysed profiles . In the general survey and half-detailed studies, it is generally considered necessary to take 1 point of observation in I0 approx., which, in the detailed studies, could be as low as 1 in 20 when the observation points are numerous.

The number of sampled and analysed profiles per unit of surface is given in the following table, it being understood that the figures are valid for fairly homogenous soils (as is frequently found in Libya). If the soils are very imbricated, it will be necessary to increase these figures.

Scale	Average number of profiles analysed by unit of surface
I/250,000	I per 50 - I00 sq. km
1/I00,000	1 per 25 sq. km
1/50,000	1 per 200 - 500 Ha
1/I5,000	1 per 80 Ha
1/I0,000	1 per 20 Ha
1/5,000	1 per I0-20 Ha

Quantity of samples per profile. It will be necessary to take one sample per horizon observed. The number may be variable in quantity 1 - 10 according to the profiles, but the general average is between 3 and 5 samples.

Location of the profiles : these are generally chosen in the most characteristic places of each unit of soil.

VIII - PRECISION OBTAINED AT THE END OF THE WORK.-

In para. VI of the contract the degree of precision required of the contractor is foreseen, followed in para. VII (7-1 and 7-2) the number of observation points and analyses.

Generally speaking, the number of observation points foreseen in VII is sufficient to obtain the precision requested in VI. In certain cases, - badly defined units of soil, mixed one with the other without a clear boundary, it could be impossible to reach such precision.

The contractor should indicate honestly :

a) in the studies on a large scale (1/10,000, 1/5,000; 1/15,000) the degree of precision that he thinks he has obtained, above all where the question of uniformity of units of soil is concerned, and the hydrodynamic characteristics if irrigation is foreseen.

b) in the studies at a smaller scale, the contractor can mention in his report and on the maps the soil complexes, when it is not possible to separate the soil units at the scale of the map.

c) in some cases, he can demand to the administration to make supplementary auger-holes, pits, trenches and soil analyses in order to obtain a more complete precision in characterising various soil units and delineating their boundaries. If this application is agreed by the administration, rider will be added to the contract for that supplementary work.

IX - PRESENTATION OF FINAL DOCUMENTS.-

9.I. General Report. This report should include the following points, preferably in the order given below :

a) a fairly rapid study of the natural status : parent material, climatology, natural vegetation, land use.

I will be necessary to note the number of days of rainfall, and data on evaporation if such exists.

If the pedologist has received information on the depth, salinity, variations and the alimentation of the underground water these should also be mentioned.

b) an extensive commentary on the pedological map which should include all the observations which it has not been possible to write in on the map (e.g., intergrade from one unit of soil to another, etc ...).

c) the morphologic description, its place in the classification and analytic data for each unit of soil. In order not to overcomplicate the text, only the most characteristic profiles and the analyses should be included; the complete list of the profile descriptions and analyses being given in the soil index cards.

d) practical recommeddations for each soil unit : choice of cultivation, irrigation possibility, feasibility of a natural drainage or the necessity for an artificial drainage, desirable agricultural experiments, study of the surrounding conditions (plant evapopers-piration).

e) a commentary on the land capability map and on its legend; it will be particularly necessary to develop the part concerning works to be carried out (removal of stones, levelling, banking up against erosion, etc ....), the possibilities of implantation of new cultivation giving their limiting factors (depth of soil, salinity, available soil in the studies on a large scale - 1/5,000 and 1/I0,000.

f) a commentary on the erosion map which will indicate the means of remedying the situation, if it is necessary, and recommendations for the future : cultivation systems which help to avoid erosion, contour bank cultivation, wind-screens, fixation of mobile sand.

9.2. A pedological map at the scale requested in accordance with paragraph 4-2, the soil units showing sub-groups, family, series, type or phase. It shall be printed in different colours.

The studies on a large scale (1/I5,000 to 1/5,000) it will be necessary to allow for a pedological map reduced to a scale of 1/50,000 or 1/I50,000 (according to the general map foreseen in that particular region), in such a way that this card can be included in the general pedological map without supplementary work being done.

The Contractor should be in possession of the standard colours and use them (Munsel colour chart shall be preferably used).

9.3. A land capability map on the same scale (printed in different colours), using American-type classifications, and showing clearly the soil divisions and sub-divisions which should receive the same treatment and have the same type of cultivation (capabilities). This map has to be taken directly from the pedological map, making use of standard colours according to the American pettern.

9.4. An erosion map at the same scale. This map will localise actual erosion, and show methods for remedying same, as well as indicating precautions to be taken in the future.

In the studies on a small scale (1/250,000) this map can be combined with the pedological map by means of symbols.

9.5. A map showing the location of the profiles described and analysed at the same scale. This map could be included in the pedological map, if that one is not too overloaded.

9.6. Soil Index Card for each profile described and analysed, that is to say those for which samples have been taken. (Annexe II). This card shall indicate the description of the profile horizon by horizon, the conditions of the surrounding (location, vegetation, geology, humidity) and show all analyses made. If, as is desirable, the Libyan Government considers the purchase of a computer for the processing of the information, the index card should be designed or re-designed according to the computer company's specifications.

9.7. Preliminary Report. It is often useful to have a preliminary report, indicating the status of the works at a given moment. The submission of such a report should be foreseen either at the time of signing of the contract or be requested several monthes in advance.

It is evident that the preparation of such a report will fall entirely on the pedologist working on the site, and that during this time he will not be doing anything else.

Despite their need for such a report, the authorities in charge of its evaluation should not request such a preliminary report (accompanied by a schematic map or not) until the prospection of the site has been completely finished.

9.8. Special case of the combined pedological-phytoecological studies at 1/250,000.

The scale of this work having been stated, the final documents can be reduced to the following :

- a pedological report
- a phyto-ecological report
- a pedological map showing the symbols for the "land capability", the types of erosion and the localisation of the profiles.
- a phyto-ecological map showing the vegetal associations and grazing capabilities.

9.9. Number and distribution of copies. Generally speaking, one foresees an insufficient number of copies, to such an extent that at the end of a few years, they are all exhausted. It is also necessary to allow for the provision of 2 copies per library in each of the services interested.

For a small study destined for an immediate and practical aim of purely local interest, I5-20 copies are often sufficient.

On the other hand, if it concerns the studies of a general character, such as the pedological coverage of the country, it is usual to exchange scientific publications between different countries. Sometimes, some libraries even buy them. It is necessary therefore to make allowance for 400 copies, often 500 or 600.

X - TIME SCHEDULE.-

Both parties have their respective obligations.

I0.I. The Administration should give to the Contractor all documents in his possession at the time of signing of the contract, if possible, or else within a very short period of time, i.e. I5 - 30 days. These are the documents cited in paragraphe 33-1 of tender documents.

I0.2. The Contractor should indicate the time he requires to complete his study, an approximate date for the submission of his final report, as well as the duration of the different stages of his work.

For a total period of one year, each of the necessary operations could take the following schedules :

Examination of existing documents and aerial photos	2 monthes
Preparatory work on site	I5 days
Proper prospection of the site	4-5 monthes
Preparation of report, analyses, printing of maps	3-4 monthes

The above figures can be taken on average. Very often, the analyses and the printing of the maps require a bit more time ; but this fact should be mentioned at the time of signing of the contract by the Contractor - or else he will be liable to the penalties according to the law.

XI - PRESENTATION OF ACCOUNTS.-

The Contractor shall present an estimate which is as detailed as possible. In order to give a better idea, there follows a distribution of the posts in a pedological study :

	About
Salaries and travel expenses of the company's technicians	40%
Salaries for local labour and material expenses (such as vehicles)	20%
Analyses	15%
Preparation of report, printing & duplication of documents	25%
Total	100%

Or, if a distribution by successive stages is required, the following may be used :

	About
Preparatory studies and pedological work on the site	55%
Analyses	20%
Syntheses, preparation of documents, designing of the maps	20%
Duplication of the documents	5%
	100%

As is the case for all tables given, the figures can be counted as average only, and should serve only to control the distribution of expenses made by the companies.

XII - RIDERS AND ANY MODIFICATIONS MADE TO THE CONTRACT.-

Every country has its own rules for establishing modifications to any contract.

In any case, it is a good thing to recall that any modification made to the contract after signature generally costs much more than if it had been included in the original contract before signature.

But it is impossible to foreseen two kinds of things which can appear during the course of study.

At first : the pedological prospection of the site can show some unknown important problems or very fertile areas which will require supplementary studies.

These studies will preferably be done by the contractor who had indicated same.

Secondly : in certain areas, in order to have more complete information on soil characteristics or delineating most precise boundaries of very imbricated soil units, the contractor may demand to the administration a rider for some supplementary work.

The agreement of Administration, of course, is requested for any application by the contractor.

C H A P T E R X

COST OF PEDOLOGICAL STUDIES

I°/ Preface

All prices mentioned in that chapter are calculated for the year 1967.

They are proceed from net costs of pedological studies in France, Tunisia and Morocco and are corrected and adapted to Libyan conditions.

Numbers quoted here are given as an estimation of net cost per hectare of studies in all the scales (1/250,000, 1/100,000, 1/50,000, 1/25,000, 1/15,000, 1/10,000, 1/5,000) as well as for a complete pedological study on two different sheets of topographical maps (scales : 1/250,000 and 1/50,000).

It is obvious they are only representing an average amount, which can be changeable according to local conditions : for instance in Cyrenaïca because large areas of rocky soils and barren rocks, net cost of a pedological mapping can be decreased proportionately to their extent.

In spite of cerefulness brought in establishing these costs, an adjustement will be necessary for each separate study;

2°/ Percentages of different expenses in pedological work

Percentages quoted hereunder are including every job in office and on the site as well printing and copying of ducuments

Salaries of scientists in Libya	about 40%
Local employees on the site	
vehicles and their maintenance	about 20%
Analyses	about 15%
Work in office abroad	about 15%
Drawing, printing maps and making fair copies	about 10%

Of course these percentages are a little bit changeable regarding to various scale :

For instance pedological work at large scales (1/I0,000, 1/5,000) is often including higher percentages for salaries of scientists (44%) and for work in office (20%) and lower percentages for local employees and vehicles (about I5%) and analyses (about 11%)

3°/ Net cost per hectare

The following figures are concerning average agricultural and grazing soil condition in Libya. In certain places, expenses will be lower (rocks, sand dunes, homogeneous soils) and in other places they will be higher (very imbricated soils).

These costs are calculated for soils of agricultural and grazing value with a certain rate of rocks, very salted soils or sand dunes where pedological studies must be made very quickly and cheaply according to poor benefit resulting from these studies.

Scale	Net cost per Hectare £ L
L/250,000	0,045
1/I00,000	0,25
1/50,000	0,85
1/25,000	2,80
1/I5,000	5
1/I0,000	7,80
1/5,000	I0

In Fezzan valleys where French Mission has recommended to establish a topographical map at a scale of 1/50,000 , net cost can be estimated at 0,80 £ L per hectare according to local conditions.

4°/ Net cost of pedological study per map sheet (scales : 250,000 and 1/50,000). Topographical maps in Libya are made at two scale 1/250,000 and 1/50,000.

Net cost of pedological study (including work on the site, report, analyses and maps) for one entire sheet of these maps will amount to :

Scale	Sheet area km2	Net cost (Libyan Pounds)
1/250,000	I,600	55,250
1/50,000	650	72,000

5°/ Net cost of Pedological studies in Libya.

5.I. First step

Scale	Location	area km^2	Estimation of Net Cost Libyan Pounds
1/50,000	Tripolitania	25,000	2,I25,000
	Cyrenaïca	8,800	748,000
1/250,000	Tripolitania	55,000	248,000
	Cyrenaïca	27,000	I23,000

In Fezzan valleys, the area to be studied must be delineated according to available water supply.

5.2. Second step : detailed survey.

The second step of pedological studies is depending on the results of the first step. It is not possible therefore to give an estimation of expenses.

6°/ Conclusion :

Pedological studies are very expensive. In Libyan areas where noticeable agricultural and grazing practices are existing, the amount is arising (evaluation made in September I967) to 3, 244,000 Libyan Pounds only for the first step.

It is important for the Government of Libya to follow an order of priorities in order to get profits from these expenses. A contractor control must be necessary in order to limit cost of pedological studies notwithstanding to the quality requested.

CONCLUSION

From May to September I967, the pedologist of the French Mission made the following works :

- study of documents and works already done.
- programm of pedological studies in two steps. This programm is detailed for small scale (first step) and not detailed for large scale (second step) which depends upon the former step.
- evaluation of needs in scientifical personal and net cost of pedological studies.
- tender documents for a great part of the country where are noticeable agricultural and grazing practices.

This document is carefully made and is trying to adapt to Libya modern data of pedological science as well as to include some advisable aims and purposes.

However it is evident that in a few years, perhaps in a few months, certain data will be outdated and some aim will be changed.

Beside this fact, one tender document is always perfectible; according to first experiences of its use, it will be often necessary to make some rectifications, complements and changes in the future.

Its fulfilment should be checked on the spot by competent inspector.

Its practical and scientifical value should be verified by top experts.

Results conclusions and consequences of pedological studies should be estimated by these experts from three points of view :

- necessity of complementary study
- agronomic and agricultural consequences
- adjustement to general politics of Government of Libya.

SECOND PART

TENDER DOCUMENTS

PREFACE TO TENDER DOCUMENTS

One tender document is composed of three sections.

1. General section which is common to every tender document. It is mainly an administrative section.

2. Changeable section, which is a technical section. It is different for each case. Four changeable sections are presented here :

- one for phyto-ecological and pedological study in semi-desert areas at a scale of 1/250,000
- one for Geffara; pedological study at a scale of 1/50,000
- one for rocky areas (west Mountains, Green Mountains, Djebel Akhdar); pedological study at a scale of 1/50,000e
- one for oasis : pedological studies at scales of 1/5,000 and 1/10,000.

3. Annexes : there are four annexes

- Annex 1 : changeable.

It is presented in way of a map attached to every changeable section.

This map is only a sketch map; it will be necessary to complete it at the real scale of the study, just before public amouncement of every tender.

- Annex 11 : common to every tender document. Presenting a model for soil index card.
- Annex 111 : common to every document; presenting a list of recommended soil analyses with their bibliographical references.
- Annex IV : common to every document. Presenting French soil classification in two issues. (Annex IV-A and Annex IV-B).

TENDER DOCUMENT

CONTRACT FOR PEDOLOGICAL STUDIES

N° ..... Amount .....

Agreed ..... (date ..... Approved ..... (date).....

Type of contract : a voluntary agreement has been entered into by the undersigned :

1 Ministry of ..... (Agriculture), (Planning) .....
represented by Mr ..... (Name) ..... (title)
to whom full powers have been given by the Ministry to act on their behalf, hereinafter referred to as "administration"

and

2 Mr .....(Name) (title) ..... who is acting on behalf of ..... (Company's name) .....
Hereinafter referred to as "tendering contractor" or "contractor".
This contract includes ..... (number) pages, with 37 articles
Annexes of the contract include ..... (number) pages.
Each page is numbered and the both parties agreed to put their both signatures on the lower part of each page.

Both parties have agreed as follows.

TENDER DOCUMENT

ADMINISTRATIVE SECTION COMMON SECTION

ARTICLE I - LAW GOVERNING THE CONTRACT.

This contract had been concluded in accordance with the Libyan Law and it shall therefore be governed by and construed and interpreted in accordance with the provisions of the Libyan Laws. In case where no provision in these Laws are applicable, reference shall be made to other legal sources acknowledged in the Libyan Law and to well established international practice and usage with respect to works similar to which the contract relates.

ARTICLE 2. - GENERAL OBLIGATIONS.-

The contractor shall respect and observe local laws, regulations, decisions and orders issued by the administrative authorities within the limit of their administrative competence, as well as the technical obligations of the undersigned contract and annexes.

He shall respect and observe local laws customs and traditions.

He shall immediately notify the Administration of any things which they may constitute an obstacle preventing him from discharging their duties in the manner stated in the contract.

ARTICLE 3. STAFF REFERENCES.

The contractor is obliged to mention the normes of their qualified engineers who shall execute the work and shall attach a copy of their University or Engineering School titles and detailed references of their works previously done in soil studies. This list will be attached to the contract.

ARTICLE 4 - COMPANY REFERENCES.

4.I. The contractor will be obliged to mention in way of a list the work previously done by his company in various countries. This list will be attached to the contract.

4.2. The contractor shall declare under oath and under penalty of conviction of the law, that the company which he represents is constitutionally correct and registered according to the laws of its own country.

That it is not bankrupt nor under judicial liquidation.

That none of its directors, managers or administrators has been convicted for unprofessionnal conduct.

ARTICLE 5. PERSONAL AND MATERIAL ENTERING INTO LIBYA.-

The contractor will be free to send to Libya the number of personal, cars and other material that he judges convenient for his work, according to a list given by himself at the signing of the contract.

Top engineers

Engineers

Assistants

Cars (custom duty free)

other materials (customs duty free).

ARTICLE 6 . COMPOSITION OF THE TEAMS.-

The contractor should be permitted latitude in forming his own soil survey teams, providing that he conforms his work to the aim, purpose and time limits of the contract and his expenses to the article 34 of the contract. The contractor will give to the administration the foreseen time shedule for every member of his staff and will let know the administration, in writing, about every change.

ARTICLE 7 . GUARANTEE.-

The contractor shall pay a guarantee of £ L ..... as security for his obligations which shall not form part of any advance to be paid. The whole amount of the guarantee shall be payable into ..... (Bank) within a fortnight after the signing date.

The guarantee shall be refunded to the contractor one calendar month after the administration has received the documents ordered under article 3I, ,on the condition that the documents conform to the terms of the contract.

This guarantee shall be confiscated by the Government of Libya in case of cancellation of the contract by the contractor and in case of serious breach and error in the provision of the contract or severe default on the part of the contractor.

ARTICLE 8 - EXPENSES TO THE CHARGE OF THE CONTRACTOR.-

The contractor shall be responsible for all expenses of the following nature incurred in connection with the study :

personal,

travel and transportation on the site,

purchase of vehicles and materials and their maintenance,

analyses

preparation of reports

printing of maps

copying of documents

Also he is obliged to include the cost of all taxes and duties in accordance with the laws in force, which shall be made known to the contractor by the administration.

ARTICLE 9 . ADVANCE PAYMENT.-

The contractor may request advance payments at intervals of ..... in proportion of work done at that time.

ARTICLE IO . FINANCIAL RIDER.-

If the study is carried out during a period of 6 months one year I8 months * after the signature of the contract, both parties shall agree to make proportional increases of the price, to be fixed by mutual consent.

ARTICLE II . ANNEXES.-

The contractor asserts that he has thoroughly read the annexes 1, 11, 111, 1V, and that he will acccordingly be bound by their obligations as well the obligations of the contract.

ARTICLE I2 . ADDITION TO THE PRESENT CONTRACT.-

Any modifications to the contract during its course of execution shall be made by codicils which shall be agreed upon by both parties.

ARTICLE I3 . OWNERSHIP OF DOCUMENTS.-

The administration is the sole owner of the studies ordered and of the documents resulting therefrom.

I3.I. As a consequence, the administration shall have the right to make use of the studies and documents in any way that shall be judged fit and right; but, in every case, the name of the contractor shall be mentioned.

I3.2. ** EITHER : the contractor shall retain the notes and the overlays of maps provided that he will remit to the administration any supplementary copies, according to the terms laid down in a subsequent agreement established within a period of 5 years after the end of the study.

** OR : the contractor shall hand over to the administration the means whereby the latter may make supplementary copies on his own behalf.

* Score out unnecessary words and numbers.
** Score out unnecessary sentence.

I3.3. The contractor shall be authorized to make use of any information acquired during the course of his studies for the purposes mentioned hereunder :

- publication of a scientific nature
- persuasion of his work in other areas
- information to : university, agricultural research stations, officials and, in this latter case, he shall inform the administration immediatly in writing.

I3.4. The contractor and his agents shall be sworn to professionel secrecy concerning all information and documents gathered during the course of his work, according to the exception quoted in paragraph I3.3.

ARTICLE I4 . CHOICE OF SUB-CONTRACTOR.-

For some of the work to be carried out, the contractor will be free to make use of subcontractors on the condition that he remains personally responsible towards the administration and third party. For such purpose, the contractor shall ask for the written consent of the administration which will be tacitly agreed upon if the administration has not replied in writing within one month.

ARTICLE I5 . ENTIRE RESPONSABILITY OF THE CONTRACTOR FOR DAMAGE TO THIRD PERSONS AND TO THEIR PROPERTIES.-

The contractor is entirely responsible for damages and injuries to third persons and their properties during the different phases of his work.

The contractor shall pay any sum awarded by court judgement to be paid as a result of claim for any reason, when direct negociations fail to resolve them. In case of failing in payment, the given guarantee (article 7) will be used as a provision.

ARTICLE I6 . OBLIGATIONS OF THE ADMINISTRATION.-

I6.I. The administration shall furnish the contractor with information in this possession, and in particular :

- climatical and geological information
- topographic documents at the scale required for the work-programme
- aerial photographs at the same scale or preferably larger
- list of projects concerning the region under study, together with their aims and purposes.

If the supply of any documents is exhausted or not available, the administration shall indicate to the contractor the means of obtaining copies and shall help him in this task.

I6.2. The administration shall undertake to obtain from all interested local authorities all facilities needed to penetrate both public and private properties.

They shall inform the population and its representatives of the objectives in mind and of the means to be used (pits, trenches, boring, sample taking, etc ...).

They will take care of any difficulties which could ,arise with the local authorities and the inhabitants.

I6.3. The administration shall give the contractor introductions to any person or organization in a position to give information concerning the study.

I6.4. If it is not available at the scale desired, the administration shall have a cover made by aerial photos of the area under study. This should be complete and in the hands of the contractor at least two months before the work is commenced on site.

ARTICLE I7 . COMPETENT OFFICIALS.-

The competent officials for the different operations of the study will be :

- Mr ..... to receive work
- Mr .....for financial matters
- Mr ..... information officer
- Mr ..... to act as liaison officer for work on the site.

ARTICLE I8 . CONTROLLING THE FULLFILMENT OF THE CONTRACT.-

I8.I. According to the advices of Libyan governement soil survey experts, the administration will choose Mr ..... (name and title) ....., as inspector for the work described in this contract. He will mainly control the following points, which are examples and not an exhaustive list.

- that the contractor follows the special clauses of the pedological work on the field as mentioned in the contract.

- that the contractor does not commit serious breaches in observing articles, aims and purposes of the contract. He shall determine if these breaches are justified by the special conditions of the work on the site.

- that the contractor does not use any information or bibliographical data as a substitute for his proper work. Such data should be considered only as a help.

- that the contractor does not commit any serious technical errors, does not supply incorrect information and does not disgress from the purposes and aims of the contract.

- that the contractor does not contravene to the general lines of the contract in any way.

I8.2. The inspector shall have to meet with the contractor surveyor and pedologists to make clear the possible interpretations of the contract, on his own request and on the request of the contractor.

He shall give advice and opinion to the surveyor pedologists and scientists either informally or in writing.

I8.3. The inspector shall verify the advancement of the work in examining rough soil maps and drafts and in checking pits and analyses. This control must take place at least each three months and every time that an advance/payment is requested by the contractor.

I8.4. The contractor agreed that every year a top expert comittee may give advices and judgement over the scientifical and practical value in pedological documents requested by the contract and furnished by the contractor. This comittee shall be composed of :

- pedologist at least ten years expreienced in soil genesis problems and in soil classification.

-pedologist or agronomist at least ten years experienced in problems of soil conservation and land reclamation.

- soil chemist at least ten years experienced in soil chemistry

- soil physicist at least ten years experienced in soil physics.

ARTICLE I9. SETTLEMENT OF DISPUTES.-

Any difference arising out of the application or interpretation of this contract with direct negociation between contractor and inspector quoted in article I8 fail to resolve shall be referred to a board of arbitration consisting of three persons : one to be nominated by the administration, another by the contractor and the third who shall be chairman will be elected by the two nominated members themselves. Failing agreement to elect the chairman, he shall be chosen by the court quoted in article 20.

ARTICLE 20 . COURT COMPETENCE.-

In case of any severe dispute or disagreement, the powers of the court of ..... shall be recognised and full validity given by both parties.

ARTICLE 2I . LANGUAGE.-

2I.I. For contract and tender documents, the arabic text is the text applicable for the contract interpretation. But it is mutually understood and agreed that the specifications and drawings shall be in English language; the ministry certifies to the best of its belief and knowledge that the English translation is true and accurate.

2I.2. Documents, reports, map legends furnished by the contractor to the administration shall be written in English language.

PEDOLOGICAL AND PHYTO-ECOLOGICAL SURVEY

Scale 1/250,000°

in TRIPOLITANIAN* CYRENAICAN* SEMI-DESERT

TECHNICAL SECTION CHANGEABLE SECTION

ARTICLE 22 - EXPLANATIRY STATEMENT.-

The Ministry of ..... through the services of Mr ..... contractor, and under the direction of Mr ..... administration inspector, has decided to make study in the region covered (totally or partly) by sheet N° ..... of the topographic map at I/250,000°.

The total area to be studied is about :

60,000 sq-km in Tripolitania *

30,000 sq-km in Cyrenaica *

Soil and vegetation study shall be made to define scientifical and practical characteristics of soils in order to use them on a rational basis for agricultural and grazing practices.

ARTICLE 23 - OBJECTIVE OF AGREEMENT.-

The object of this agreement is therefore to entrust the contractor combinating pedological and phytoecological study in a general survey at I/250,000 scale of soils and vegetation of the semi-desertic region as defined under article 24.

The basic topographic documents will be the geographical map of Libya at the scale of 1/250,000, and aerial photographs at the scale of .....

ARTICLE 24 - DEMARCATION OF THE BOUNDARIES.-

24.I.** In Tripolitania, the area to be studied is situated in western Geffara and Southwards of West Mountains (Djebel Nefusa) from Tunisian Border to Syrte Gulf, approximatly between isohyets I50mm and 75mm.

* Score out unnecessary words and numbers

** Score out unnecessary paragraph.

It is indicated on the annexed map in black ink showing its limits; these maps (ANNEX I) will serve as reference in case of any dispute.

24.2** In Cyrenaïca, the area to be studied is situated southwards of Green Moutains and Djebel Al Akhdar from Gulf of Syrte to Egyptian Border, located approximatly between isohyets 150mm and 75mm.

It is indicated on the annexed maps in black ink showing its limits; these maps, ANNEX I, will serve a reference in case of dispute.

ARTICLE 25 - GENERAL LINES OF THE STUDY.-

25.1. Scientifical objective

At first the contractor shall plan his work from scientifical point of view; he shall make summary bibliographical studies of climatology, geology and hydrogeology of the area under consideration.

On the site, the pedologist and botanist shall work together in the same team, assisting one another.

Pedologist shall study mainly :

Soil genesis classification and properties
Soil plant relations
Calcareous and gypseous crust location
Saline and alkaline problems
Erosion problems (wind and water erosion)
and possible means to prevent soil erosion
Protection against mobile sands and sand dunes

Botanist shall study mainly :

Vegetation carpet
plant association
Soil-plant relation in each main soil unit
Influences in plant-growth of human activities (grazing and dry-farming).

Such study at this large scale (1/250,000) shall be carried out mainly by crossed sections with the help of aerial photographs. Notwithstanding, the contractor must be carefull regarding river valleys where some cultivation is made after every flood (flooded dry-farming), regions where formerly there was a prosperous farming husbandry during Roman times, and areas where soil is deep and fertile enough for irrigation purposes.

** Score out this paragraph if it is unnecessary.

He shall carefully characterise their main soil and vegetation features. He shall locate on his map and report these zones, indicating if in his opinion, a detailed study shall be made in the future.

25.2. Scientifical ability

As science of Pedology is developing continuously, the contractor shall make every effort to apply the most up-to-date methods in analysing and classifying soils and vegetation as used by pedologists and phyto-ecologists in the Mediterranean Basin in general and in the Maghreb particularly, that : now and in the future, comparisons can be made of the experiences and results with countries having similar climate vegetation soils and similar problems.

For that purpose, he shall use :

- in Pedology, the French soil classification and will give the corresponding names in American Seventh Approximation.

He shall delineate soil units in the area under study, using the following system :

Soil class

Soil sub-class

Soil group

Soil sub-group

Soil family

He shall employ symbols to characterise erosion (forms and intensity) in his map

- in Phyto-ecology, the system sharpened by "Centre d'Etudes Phyto-ecologiques" in Faculté de Botanique, University of Montpellier (France)

The contractor shall be careful to note human practices (grazing - eventually dry-farming) in order to estimate the amount of modifications in natural landscape regarding these factors; he shall use symbols on map to represent their influence. In describing plant association, he shall give latin and if possible vernacular names.

25.3. Practical objective

According to the scientifical study, regarding soil and vegetation units previously delineated in this study, he shall try to obtain the most complete information possible on the agronomical issues resulting therefrom.

He shall specially delineate :

- areas where extensive grazing is only possible and possible amount of cattle
- areas which are needing protection against unsteady sands.

- areas where flooded cultivation is used with possibilities to improve

- areas where irrigation is possible (according to soil qualities) for winter fodder plants and new crops.

It is the duty of the contractor to make known and give his own opinion regarding every problem encountered during the course of his study, even if it is not specifically mentionned in the contract.

25.2. Practical ability

The contractor shall furnish in his final documents, maps and report, sufficient information to be directly used for land improvement program.

For that purpose the contractor shall take advice from the American classes System of Land Capability.

He shall note in his report and on his map (using symbol and surcharge) every area where irrigation practices are possible.

It is his duty to study more carefully these areas, carrying over work saved in zones which are unavailable for any agricultural and grazing purposes (rocks, crusts, sand dunes, very salty soils).

25.3. Under opinion of the inspector, he may offer to the administration to prepare more detailed study of certain areas which are more interesting for agriculture (see Article 37).

ARTICLE 26 - PLAN OF STUDY.-

The contractor shall carry out the following operations preferably in the order indicated below, although certain may be carried through during the whole course of the study.

26.I. Examination of existing documents

Topographical, climatical, phyto-sociological, agronomical.

He shall prepare a detailed bibliography of these consulted studies and articles and shall attach such to his report. If necessary, he will also indicate the areas where available documentation appears to be inadequate

26.2. Aerial photographs

The contractor shall study carefully aerial photographs both at the office and "in situ". At first, he will try to mark main features of the landscape, then to verify on the spot the corresponding soil units and plant associations.

If it is considered necessary, he shall prepare a photoplan.

26.3. Preliminary study

The administration and the contractor agree that during preliminary study, botanists and pedologists (or at least senior scientists) may go well beyond the demarcation of the above mentioned boundary in order to allow the contractor to get familiar with nature of the problems brought by vegetation, soil and agriculture of the region over the whole bordering section to be studied.

Such study will take about I5 days per year, taking place at once or several times according to the necessity of the study.

26.4. Prospection of the site

He shall make a study of the area delineated under Article 24 and Annex 1.

With the help of aerial photos, he shall try to determine main soil units and plant associations and shall verify by cross sections.

He shall observe natural vegetation and soil, digging trenches pits and auger-holes describing plant associations and soil profiles, taking samples; he shall make an evaluation on the spot of the properties and characteristics of soil and vegetation according to article 25. He shall collect every information helpful to him.

26.5. Soil analyses

He shall determine in Laboratory the chemical and physical characteristics of the collected samples, according to the methods recommended in ANNEX III.

If, in exceptional case, he is using other methods, he should indicate his reasons and state most precesely the methods in way of bibliographical references.

He shall note in his report a brief reference of every method used in order to make it known by any reader.

The administration reserves the right, if necessary, to request supplementary analyses of certain samples, analyses which can be incorporated by means of rider; for this purpose, samples should be filed and kept for a period of three years, then sent back to Libyan Soil Collection.

26.6. Final documents

He shall prepare synthesis of the elements gathered together in way of report with pedological and phyto-ecological maps as described in article 3I.

26.7. Fair copy

He shall make a fair copy and several copies of these documents in the amount requested by the Administration (Article 33).

ARTICLE 27 - SUMMARIZING OF THE OBSERVATION MADE.-

27.I. Precision of the boundaries for each main soil unit.

This precision must be obtained by means of aerial photographs, pedological trenches and pits, auger-holes, etc .....

According to the scale, the maximum error must be 1000 meters from each part of line delineating soil units (total error 2000m), and this statement of the boundaries should be understood as a margin of maximum error, which should never be exceeded.

27.2. Degree of uniformity

This degree of uniformity (or percentage of characteristic profiles in the same soil unit) must be 40% in zones where extensive grazing is only used.

It should be increased to 50% in areas available for any other agricultural purposes. When different soil units are very imbricated and their areas are too small to be put on a 1/250,000 scale map, the contractor shall define soil complexes indicating on his maps.

In phyto-ecological study, the contractor shall make effort in connecting soil units and plant associations.

27.3. Sketch on the site

Towards this end, he shall make on the site rough phytoecological and pedological maps and drafts summarizing every observation.

These maps and drafts, with daily record kept for his own reference, can be consulted by the inspector at any time on his own request/

ARTICLE 28 - NUMBER OF OBSERVED POINTS OF THE AREA UNDER STUDY.-

28.I. The contractor shall make study of the site, in depth, by means of natural cuts, auger-holes, pits and trenches.

Pits and trenches are at least I80 centimeters in depth, with sizes in width and length sufficient enough for observing profiles and taking samples in easy way.

When one soil sample is to be taken, combination of pit and auger-hole is permited in certain cases.

28.2. The average number of trenches pits and auger holes shall be approximately one per 500 hectares, with about 50% of trenches or pits. But it is the proper job of the contractor, according to the special conditions of the site, to replace pits by auger-holes or inversely, to locate his observed points in such places which suit his purpose, provided that this average number will be similar to the number of observed points.

There shall be no pit or trench in rocky and very salty soils and small quantity in sand dunes.

In particular, when he finds large area of infertile lands (rocks, crusts, very salty soils), he shall transfer to the available zones (oasis, dry-farming valley areas, fertile yet uncultivated areas) the work spared in former zones (rocks, crusts, etc ....).

ARTICLE 29 - OBSERVING PROFILES AND TAKING SAMPLES.-

29.I. Soil profile : soil profile of each trench (or pit) shall be observed and each horizon studied from top to the bottom, noticing every information and detail available for the study, according to the special way of the pedologist and the instruction given by ANNEX II.

Parent material, when it is visible, shall be studied as soil horizon.

Contractor shall pay special attention to water-table, if it is existing, its possible variation, and its influence on soil conditions.

29.2. Sampled profile : among trenches and pits under observation, contractor shall choose very characteristic profiles in each soil unit in order to take soil samples, at the average ratio : one sampled profile out of ten.

Then he shall sample every soil horizon in its entire depth, including parent material when it is soft.

The weight of each soil sample shall be approximately comprised between 500 gr and one kilogramme.

The number of samples is very changeable from one profile to another, but the average amount should be four to five per profile.

29.3. Average number of sampled profiles and samples per hectare.

According to the paragraphs 28.2., 29.I, and 29.2, the average number of sampled profiles and samples should be approximatly one sampled profile and four or five samples per 5,000 hectares.

In sand dunes and crusts, the contractor is only permited to take samples in two profiles per every large soil unit, and in rocky and very salty soils, few samples in which soils can be roughly caracterised.

Certain quantity from these samples saved in that way can be transfered to soils where an agricultural or grazing improvement is possible.

29.4. Water-samples

If results from water-analyses are not available, the contractor shall take water-samples in springs or wells or drilled-wells, when their water is used or available for irrigation practices; he shall analyse them in or er to have rough information on their properties.

When water table is found in trench, he shall take single water-sample.

29.5. Plant associations around profile.

Around soil profile and especially sampled profiles, botanist shall study vegetation and plant associations in order to define soil-plant relations.

ARTICLE 30 - ACHIEVED PRECISION AND SUBSEQUENT AGREEMENT.-

30.I. During the course of his study on the site, the contractor shall indicate in writing available areas for land improvement or reclamation: when these areas are too small to be put on 1/250,000 scale map, he shall furnish sketch maps in order to locate them on the spot (valleys with flooded cultivation, small oasis, fertile yet uncultivated land, etc ...)

30.2. He shall indicate, if in his opinion, a more detailed study is required in case of agricultural improvement in these areas, and may offer to make this work as mentioned in Article 37.

30.3. Towards the end of his study on the site, the contractor is permited to make an application to the administration for class 4 analyses, as mentioned in Article 36.

ARTICLE 3I - PRESENTATION OF FINAL DOCUMENTS.-

According to the aim and purpose of the contract and particularly to the article 25, the contractor shall hand over, every year during his study, the following documents :

3I.I. Report comprising :

- indications of natural surroundings : climatology, geology and actual land use
- synthesis of hydrological and hydrogeological information concerning surface and underground water and possible use for irrigation.
- commentary developed from phytoecological map describing plant associations, their grazing value, soil-plant relations, estimating possible amount of cattle for extensive grazing per soil unit, and briefly studying possibility of new fodder plants.

- commentary developed from pedological map and its explanatory comments which supplementary information is impossible to be placed on map.
- morphological description showing, for each soil unit, typical profile and its analytical data
- information and analyses concerning quality of water available for irrigation.
- commentary developed from land capability map with practical recommendation for each soil unit : possibility of extensive grazing (with amount of cattle), flooded dry farming.and irrigation practices, protection against erosion and mobile sands, etc ...

If existing data are used, the contractor must mention their origin, at first briefly in his report, then in the bibliography in a way of reference.

3I.2. Pedological map (printed in different colours) at a scale of 1/250,000 showing various soil units in accordance with the instructions in Article 25; location and number of sampled profiles shall be included. The contractor shall make effort, using symbol and surcharge, to indicate on the same map main features of land capability (possibility of irrigation, new land use, extensive grazing, etc ....) and of erosion (form and intensity).

If it is impossible, he must make one or two overlays.

3I.3. Phyto-ecological map (printed in different colours) at a scale of 1/250,000 showing :
- plant associations
- soil unit-plant association relations
-grazing value for flocks and live-stock of each plant-association and large soil units, with an estimate of the possible amount of cattle to avoid destroying natural conditions.

3I.4. Plant association index cards, one for each study of vegetation, describing one side various kinds and quantities of plants and on the reverse side main features of the soil unit where these plants are growing.

3I.5. Soil index cards, one for each described soil profile, showing on one side soil description in accordance with ANNEX II and on the reverse side soil analyses (if analyses are made).

3I.6. Drafts on the site : the contractor shall hand over during the whole course of his work on the spot, drafts in a way of sketch maps and soil cards which should be entered every day for his own purpose.

These drafts may be consulted by the inspector at his own request.

3I.7. Preliminary report : the administration may request a preliminary draft (report and map), under the condition advising the contractor at the date of the signing contract or two months in advance.

ARTICLE 32 - NUMBER OF COPIES.-

Then the administration shall demand the number of copies to be submited by the contractor every year during his study, preferably including the study of entire sheets of the topographical map (scale : 1/250,000).

	Number of copies	
	Local use only (1)	Local use and scientifical publication (1)
Report	20	500
Pedological map	20	500
Phytoecological map	20	500
Soil index cards	5	I0
Plant index card	5	I0

((1) on the signing date of the agreement, the administration shall determine what use it extends to make with the documents; then it will indicate the proper number of copies, scoring out the unnecessary column.)

ARTICLE 33 - TIME SCHEDULE.-

33.I. The administration shall undertake to give to the contractor all technical information on its disposal, and particularly :

- precise delimitation of boundaries of the area under study
- geological, hydrological, hydrogeological information
- climatical data
- topographical maps of the site (2)
- aerial photographs of the site (2)

Within ..... (time limit), after signature of the contract

(2) Except when the contractor has taken topographical maps or aerial photographs in hand according to codicil agreed by both parties.

33.2. The contractor shall undertake to complete the study and to submit every final document within a period of four years in Tripolitania *
a period of two years in Cyrenaïca *

In case of delay, he shall be fined according to Libyan Law, unless such delay is caused by "force majeure" or by incidents beyond his control.

33.3. Each year, on prospecting the site and in preparing final documants the contractor should observe preferably the following time limit.

	Month
Preparatory work at the office (aerial photoes, general planning, bibliographical work)	2
Preliminary work on the site	I/2
Prospection on the site	5 I/2
Preparation of drafts, analyses copying of report and maps	3

At the end of every year, final documents will be submited to the administration.

33.4. Within the time limit mentioned in paragraph 33.2, the following priorities are requested for annual work and documents.

* Score out the unnecessary words

*In Tripolitania he shall divide ,the whole area under study in four equal zones by lines going from North to South, the first year beginning his work in zone the nearest of Gulf of Syrte, continuing towards west and the last year ending along the Tunisian Border.

* In Cyrenanica, he shall divide the whole area under study in two equal zones by lines going from North to South; the first year, he shall make his work in the Eastern zone and the last year in the Western zone.

ARTICLE 34 - PRESENTATION OF ACCOUNTS.-

34.I. The contractor shall submit his estimate of expenses yearly as follows :

	Amount
- Salary of Engineers and Technicians of his company, including period required for preparation of study and period necessary to final report and analyses as mentioned under Article 26 :	.....
- aerial photographs and maps (if they are not given by administration)	.....
- vehicles and their maintenance	.....
- materials	.....
- salary of local employees	.....
- preparation of reports, printing maps	.....
- copying of documents	.....
T O T A L	.....

34.2. The contractor shall estimate net cost per hectare

ARTICLE 35 - ADDITIONS TO PRESENT CONTRACT.-

Any modifications to the contract during its course of execution shall be made by codicil or rider which shall be agreed by both parties

ARTICLE 36 - SUPPLEMENTARY ANALYSES CLASS FOUR.-

36.I. As mentioned in ANNEX III, the contractor is permited, during the course of his contract and once per year, to submit to the agreement of the administration a list of analyses class four to be done in

* Score out unnecessary paragraphs.

definite soil and water samples, according to local difficulties and problems encountered during the prospection of the site; the inspector of the administration shall attach to that list his own opinion, favourable or unfavourable, after discussion with responsible pedologists.

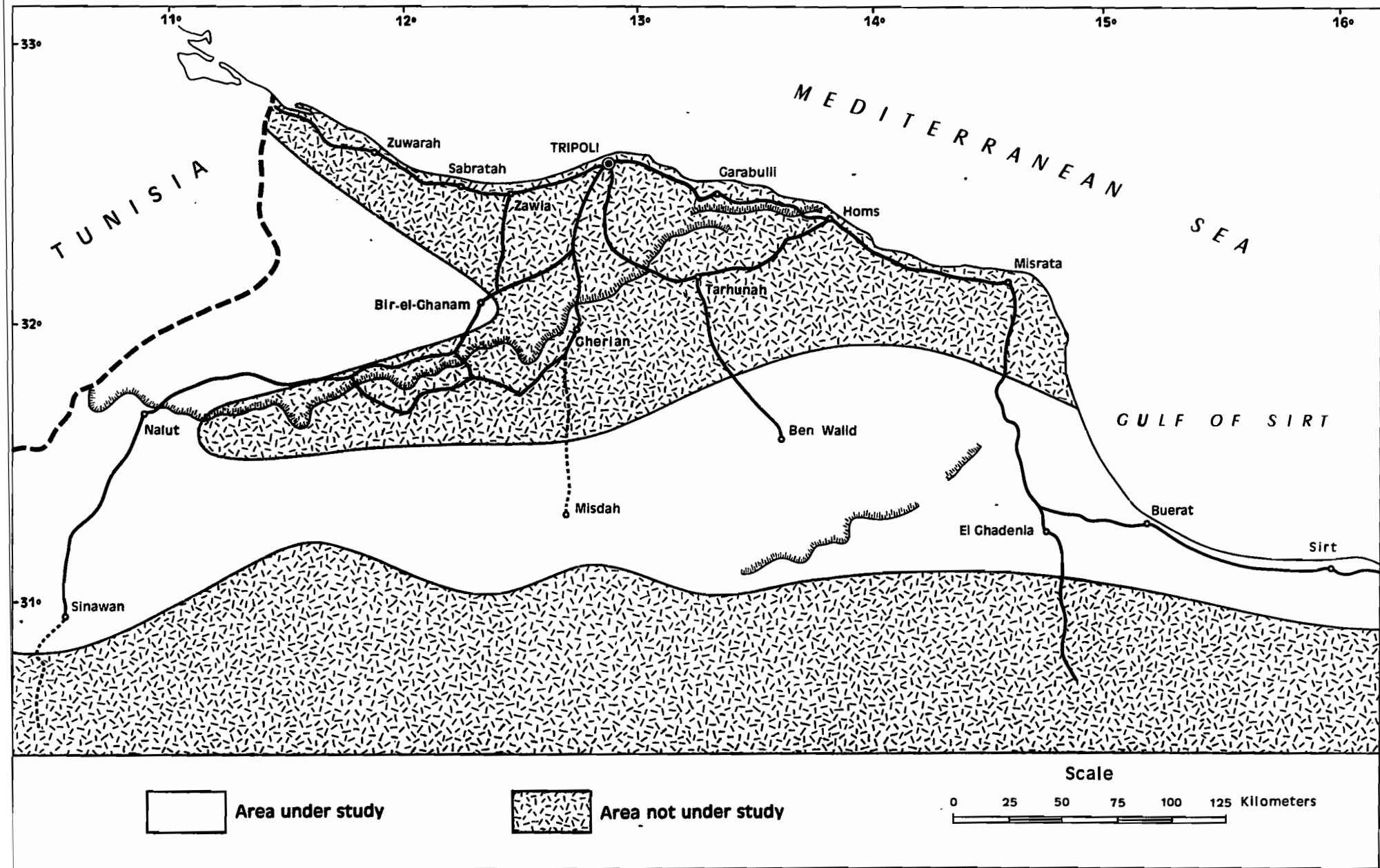
36.2. This application of the contractor will be valid under the condition which he attaches to the contract, on the date of signing, the net cost of every analyses class four, mentionned in ANNEX III.

36.3. If the administration agrees, rider shall be made between both parties for the above mentionned analyses.

ARTICLE 37 - SUPPLEMENTARY STUDY AT A LARGER SCALE.-

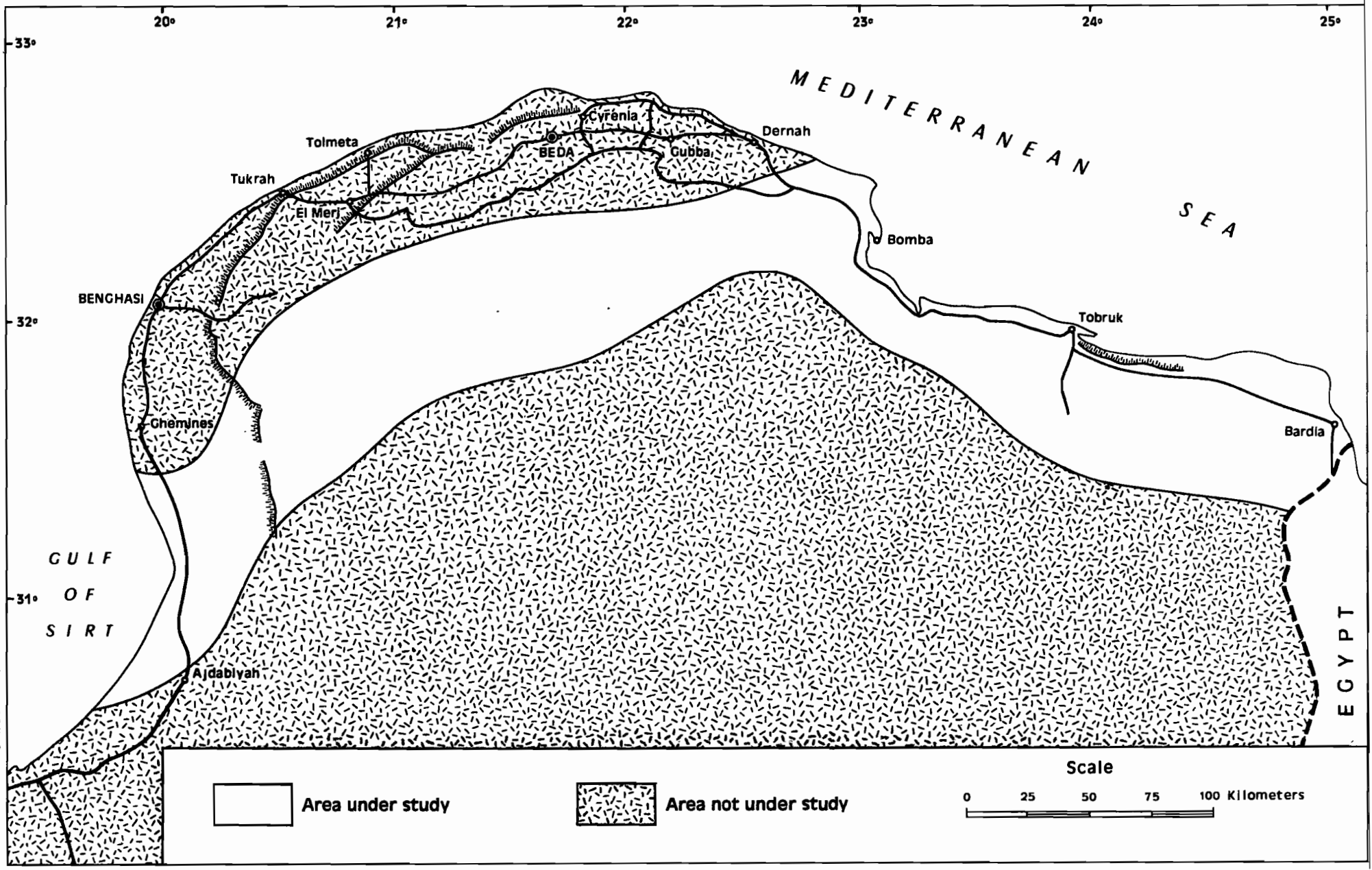
37.I. As mentioned in Article 25, paragraph 25.3. and article 30 if the contractor, during the course of his study, has found definite areas where soils are fertile and underground water available enough for agricultural purpose, the contractor may offer to the administration to make more detailed study in these areas, precising scale of the study and the approximate surface. The inspector of the administration shall attach to that application his own opinion, favourable or unfavourable, after discussion with responsible pedologists.

37.2. If the administration agrees, rider shall be made between both parties for the supplementary study.



ANNEX I - TRIPOLITANIA

PEDOLOGICAL AND PHYTO-ECOLOGICAL STUDY to be made at a scale of 1/250000



ANNEX I – CYRENAICA

PEDOLOGICAL AND PHYTO-ECOLOGICAL STUDY to be made at a scale of 1/250000

- GEFFARA -

PEDOLOGICAL SURVEY, Scale 1/50,000
TECHNICAL SECTION CHANGEABLE SECTION

ARTICLE 22 - EXPLANATORY STATEMENT.-

The Ministry of ..... through the services of Mr ..... contractor, and under the direction of Mr ..... inspector, has decided to make a study of the region covered (totally or partly) by sheet N° NI 33-I3 and NI 33-I4 of the topographical map at 1/250,000° scale. The total area to be studied is about 6800 square - kilometers.

Soil studies should be made to define scientifical and practical characteristics of the soils and their agricultural aptitude in order to use them for a modern farming husbandry.

ARTICLE 23 - OBJECTIVE OF THE AGREEMENT.-

The object of this agreement is therefore to entrust to the contractor the semi-detailed study at the 1/50,000 scale of the soils of the region as defined under article 24.

The basic topographical documents will be the geographical map at the scale of 1/50,000° and aerial photographs at the scale of .....

ARTICLE 24 - DEMARCATION OF THE BOUNDARIES.-

24.I. The area to be studied is situated in Geffara, it is indicated on the annexed maps, black ink showing its limits. These maps (ANNEX I) will serve as reference in case of any disputes.

24.2. The area to be studied is divided in natural zones as follows : (Steward land use maps)

Zone A : areas where there are now agricultural and forestry uses
Zone B : areas where there are many sand dunes
Zone C : areas now undeveloped
Zone D : areas where there are many salted soils
Zone E : coastal sand dunes

these zone boundaries are delineated in the joined maps only for a tendering purpose, mainly in order to introduce different degrees of precision and to show various aims in the requested study.

It is the proper job of the pedologist to make them precise or to abstract according to the necessities of the study.

ARTICLE 25 - GENERAL LINES OF THE STUDY.-

25.I. Scientifical objective

The contractor shall plan his work at first from a scientifical point of view; towards this end, he shall make summary studies of vegetation, climatology and parent materiels of the area under consideration.

He shall study more accurately the following points :

soil genesis and classification ; soil morphology

properties and agricultural value of various soils

calcareous and gypseous crusts and their location

saline and alkaline soil problems

erosion problems under wind and water action and possible means to prevent soil erosion.

25.2. Scientifical ability

As science of pedology is developing continuously, the contractor shall make every effort to apply the most up-to-date methods in analysing and classifying soils, as used by pedologists in the Mediterranean basin in general and in the Maghreb in particular : that, - now and in the future, comparisons can be made of the experiments and results from countries having similar soils and problems.

For that purpose, he shall use the French soil classification and will give, when it is possible, the corresponding names in American Seventh Approximation.

He shall delineate soil units in the area under study, using the following system :

Soil class

Soil sub-class

Soil group

Soil sub-group

Family

Series (if possible)

In the latter divisions, he shall use symbols to characterise the main features of soil texture.

25.3. Practical objective

According to the scientifical study and soil units previously delineated in this study, he shall try to obtain the most complete and possible information on the agronomical issues resulting therefrom.

Zone A.

Irrigation and drainage possibilities

Danger due to erosion on cultivated lands and practical means to stop it

Promotion in agricultural uses

Possibilities of new crops and agricultural practices

Reclamation of uncultivated lands

fertilizers and manure needs.

Zone B and C

Protection against soil erosion and unsteady sands

Possibilities of land reclamation for agricultural practices

Necessity of forest improvement

Zone D

a) where there is non salty soil, the same way has to be applied as in zone A

b) where there is a bit salty soil, possibilities of some cultivation and grazing (Barley and atriplex cultivation)

Zone E

Assessment of unsteady sands

It is the duty of the contractor to make known and give his own opinion regarding every problem encountered during the course of his study, even if it is not specifically mentionned in the contract.

25.4. Practical ability

The contractor shall furnish in his final documents, maps and reports, accurate information, so that it can be directly used by the agronomists in charge of land improvement and reclamation.

For that purpose the contractor shall employ the American classes System of land capability.

But he must be careful that this system is not always well adapted to Mediterranean and desertic conditions.

He has latitude to make supplementary subdivisions in these classes, and he will use symbols to characterise particularly soil-plant capabilities, irrigation and drainage possibilities, various land improvement and reclamation (cultivation, grazing), work to be done, and any other duties he judges convenient.

ARTICLE 26 - PLAN OF STUDY.-

The contractor shall carry out the following operations preferably in the order indicated below, although certain of them may be carried through during the whole course of the study.

26.I. Examination of existing documents

Topographical, climatical, geological, geormorphological, hydrological, pedological, phytosociological, agronomical.

He shall prepare a detailed bibliography of the studies and articles consulted and shall attach such to his report : if necessary, he will also indicate the areas where available documentation appears to be inadequate.

He shall also make synthesis of existing documents about soil and land use and verify their value on the spot, so that they can be adapted to his own specifications.

26.2. Aerial photographs

The contractor shall study carefully aerial photographs both at the office and "in situ". At first, he will try to mark main features of the landscape, then to verify on the spot the corresponding soil units.

If it is necessary, he shall prepare a photoplan.

26.3. Preliminary studies

The administration and the contractor agree that during preliminary study, pedologists (or at least senior pedologists) may go well beyond the demarcation of the above mentioned boundary in order to allow the contractor to get familiar with the nature of the problems brought by the agriculture and the soil of the region over the whole bordering the section to be studied.

Such study will take about I5 days per year taking place at once or several times according to the necessity of the study.

26.4. Prospection of the site

He shall make study of the area delineated under Article 24 and Annex 1, observing natural cuts, digging trenches and pits, descri ing profils, and taking samples; he shall make an evaluation on the spot

of the properties and characteristics of the soil according to article 25.

He shall collect every information helpful to him.

26.5. Analyses

He shall determine in laboratory the chemical and physical characteristics of the samples collected, according to the methods recommended in Annex III.

If, in any exceptional case, he is using other methods, he should indicate his reasons and state most precisely the methods in way of bibliographical references.

He shall note in his report a brief reference of every method used in order to make them known by any reader.

The administration reserves the right, if necessary, to request supplementary analyses of certain samples, analyses which can be incorporated by means of rider; for this reason, samples should be filed and kept for a period of three years, then sent back to Libyan soil collection.

26.6. Final documents

He shall prepare synthesis of the elements gathered together in way of a report with pedological map, land capability map and erosion map as described in article 31.

26.7. Fair copy

He shall make fair copy and make copies of these documents in the amount requested by the Administration (Article 33).

ARTICLE 27 - SUMMARIZING OF THE OBSERVATION MADE.-

27.1. Precision of the boundaries for each soil unit.

This precision must be obtained by means of aerial photos, pedological trenches and pits, auger-holes, etc ...

	From each side of the line	Total errors
Zone A . Internal and external boundaries	± I25	250
Zone B . External boundaries	± I25	250
Internal boundaries	± 200	400
Zone C . External and internal boundaries	± I25	250
Zone D . External boundaries	± I25	250
Internal boundaries	± 200	I00
Zone E . External boundaries only	± I25	250

The statement of the boundaries should be understood as margin of maximum error which never should be exceeded.

In fact, with an accurate use of aerial photographs, the average error on the boundaries should be generally smaller.

27.2. Degree of uniformity

This degree of uniformity which can be requested is varying according to the different aereas :

Zone A	Degree of uniformity	80%
Zone B	" "	70%
Zone C	" "	70%
Zone D	" 3	
	Soil not alkaline or salty	80%
	Soil weakly alkaline or salty	70%
	very salty soil	50%
Zone E	Degree of uniformity	50%

When very different soil units are very imbricated and their areas are too small to be set on map at the scale of 1/50,000, the contractor shall define soil complexes indicating on map.

27.3. Sketch map and draft on the site

Towards this end he shall make on the site sketch map and draft summarizing all observations and shall indicate entries every day for his own record sketch map and drafts can be consulted by the inspector at any time.

ARTICLE 28 - NUMBER OF OBSERVED POINTS ON THE AREA UNDER STUDY.

28.I. The contractor shall make study of the site, in depth, by means of natural cuts, auger-holes, pits and trenches.

Pits and trenches are at least I80 centimeters in depth, sizes in width and length sufficient enough for observing profile and taking samples in easy way.

When a hard rocky level is encountered in soil, one stops to dig pit in depth.

28.2. The average number of trenches pits and auger-holes are as follows :

	area Ha	Pit and trench	Auger-hole
Zone A	25	1	0
Zone B	50	1	1
Zone C	25	1	0
Zone D			
Sand soils	25	1	0
Alkaline and salted soils	50	1	2
Very salty soil	-	0	0
Zone E	I00	0	1

according to the special conditions of the site, it is the proper job of the contractor to replace pit by auger-holes or inversely, to locate his observed points in such places which suit his purpose, provided that these average numbers are observed.

Such average numbers are available only for soils which can be put to practical use; they could be increased (twice) on the boundaries of pedological units and on areas where these units are very imbricated.

When rocks (part of zone C), sand dunes (zone B, some parts of zones B and C), very salty soil (part of zone D) do exist, the pedological study shall be made by means of cross sections according to the information given by aerial photographs.

there shall be no pit or trench in rocky and very salty soil and a few numbers in sand dunes

ARTICLE 29 - OBSERVING PROFILES AND TAKING SAMPLES.-

29.I. Soil profile of each trench (or pit) shall be observed, each horizon studied from top to the bottom, indicating every information and detail available for the study, according to the special way of the pedologist and the instruction given by ANNEX II. Parent material, if it is visible, shall be studied as soil horizon. In case there is water-table existing, contractor must be careful about it, its possible variations and influences in soil condition.

29.2. Sampled profiles : among trenches and pits under observation, contractor shall choose very characteristical profiles in each soil unit in order to take soil samples, at the average ratio : one sampled profile out of eight.

He shall sample every soil horizon on its entire depth, including parent material when it is soft. The weight of each sample shall be comprised approximatly from half kilog to one kilog.

The number of samples is very changeable from one profile to another, but the average amount should be four (4) per profil.

29.3. Average number of sampled profiles and samples per hectare.

According to the paragraphs 28.2., 29.I. and 29.2., the approximative average number of sampled profiles and samples in area where agricultural, forest and grazing purposes are possible, should be approximatly as follows :

	average number of :		
	Hectares	Sampled profiles	Samples
Zone A and C	200	I	4
Zone B	500	1	4
Zone D	200	I	4
Zone E	whole zone	1	4

In sand dunes, the contractor is only permitted to take samples in two profiles per every large soil unit, and in rocky and very salty soil, few samples only in order to characterise these soils.

29.4. Water-samples

The contractor shall take water-samples in some springs or wells when their water is used or available for irrigation purpose, only in order to have information on their properties. When water-table is found in trench, he shall take one water-sample.

ARTICLE 30 - ACHIEVED PRECISION AND SUBSEQUENT AGREEMENT.-

30.I. Towards the end of his study on the spot, the contractor should indicate if, in his opinion, the required degree of precision has been achieved.

If not, he should estimate the degree which has been reached and should explain the reason in writing to the inspector.

30.2. In this latter case, with the agreement of the inspector, he may ask to the administration to make supplementary trenches, pits, auger-holes and soil analyses; this supplementary work shall be paid to the contractor on the basis of trench cost (including : digging, observing, eventually sampling) and analyses cost agreed by the both parties on the signing of the contract, (articles 36 and 37).

If this is accepted by the administration, rider will be added to the contract.

ARTICLE 3I - PRESENTATION OF FINAL DOCUMENTS.-

According to the aim and purpose of the contract, specially to the article 25, the contractor should hand over, every year during his study, the following documents

3I.I. Report including :

- indications of natural surroundings : climatology, geology, vegetation, cultivated plants.
- synthesis of hydrological and hydrogeological information regarding surface and underground water and possible use for irrigation
- commentary developed from pedological map and its explanatory comments, with supplementary information impossible to be put on map.
- morphological description showing, for each soil unit, typical profile and its analytical data
- information and some analyses about quality of water available for irrigation, and rough estimation of possible evolution in soils under the condition of irrigation.
- commentary developed from the land capability map and its explanatory notes, with practical recommendations for each soil unit : capability of irrigation and drainage, possibility of improvement of actual land use and introduction of new crops, use of necessary fertilizer, etc ...

He also shall indicate, if, in his opinion, new cultivation system is desirable and agricultural experiments useful for that purpose.

In uncultivated land, he shall study possible land reclamation for agriculture, forest, grazing and work to be done.

- commentary of erosion map, with suggestion in remedying present situation and avoiding erosion danger in the future.

(If existing data are used, firstly the contractor must mention their origin briefly in report, secondly in the bibliography in way of reference).

3I.2. Pedological map printed in different colours at a scale of 1/50,000, showing various soil units, in accordance with the instructions in article 25; this map must include location and number of profiles examined and analysed. If it is not possible another map showing location and number shall be made

3I.3. Land capability map printed in different colours at a scale of 1/50,000 showing the types of soils which can be given the same treatment to put them into the same effective use : (see ARTICLE 25)

3I.4. Erosion map printed in different colours at a scale of 1/50,000, showing the main forms of erosion by different areas and units of soil : sheet erosion, furrow erosion, gully erosion, rain-off and wind action and means for remedying and preventing them.

3I.5. Soil index cards, one for each described and analysed profile, showing on one side soil description according to annex II and on the reverse side soil analyses of samples collected in that profile.

3I.5. The contractor shall hand over, on the spot, during the whole course of the ground prospection, a sketch map and soil card drafts for daily records.

These ground drafts may be consulted by the inspector on his own request.

3I.7. The Administration may request a preliminary draft, on the condition that they advise the contractor two months in advance or at the date of signing contract;

ARTICLE 32 - NUMBER OF COPIES.-

The administration shall then fix the number of copies to be submited by the contractor every year duting his study and preferably including the study of entire sheets of the topographical map at the scale of 1/50,000.

	Number of copies	
	For local use only (1)	Local use and scientifical publication (1)
Report	I5	400
Pedological map	I5	400
Land capability map	I5	400
Erosion map	I5	400
Soil index cards	5	5

(1) On the signing date, the administration shall determine what use to make with the study and fix the proper number of copies, scoring out the unnecessary column.

ARTICLE 33 - TIME SCHEDULE.-

33.I. The administration shall undertake to give to the contractor all technical information on its disposal in particular :

- precise delimitation of boundary of area under study
- topographical maps of site *
- aerial photoes of site *

Within ..... (time limit), after signature of the contract.

(* Except if the contractor has taken topographical maps and aerial photographs in hand according to codicil agreed by both parties.)

33.2. The contractor shall undertake to complete the study and to submit every final documents within a period of five years.

In case of delay, he shall be fined according to Libyan Law, unless such delay is caused by "force majeure" or by incident beyond his control.

33.3. Each year, inprospecting the site and preparing final documents, the contractor preferably should observe the following time limits :

	Month
Preparatory work at office :	
Aerial photos ; general planning and bibliographical information	2
Preparatory work on site	1/2
Prospection on site	5 I/2
Preparation of drafts, analyses, copying of reports and maps	3

At the end of each year, final document will be submited to the administration.

33.4. Within the time limit of five years, the following priorities are requested for annual work and document (covering entire map sheets according to boundaries delineated on the map Annex I).

First year	Zavia and Azizia areas about I300 sq-km
Second year	Tripoli - Ben Gashir areas about I400 sq-km
Third year	Garabulli and Eastward of Tripoli about I400 sq-km
Fourth year	Sabratah, Zuara area about I360 sq-km
Fifth year	Remainding area

..../....

ARTICLE 34 - PRESENTATION OF ACCOUNTS.-

34.I. The contractor shall submit his estimate of expenses yearly as follows:

	Amount
- Salary of Engineers and technicians of his company, including period required for preparation of study and period necessary to final report map and analyses as mentioned under Article 26	.....
- Aerial photographs and maps (if they are not given by administration)	.....
- vehicles and their maintenance	.....$\frac{1}{4}$
- Materials	.....
- Salary of employees	.....
- preparation od reports, printing maps	.....
- copying of documents	.....
T O T A L	.....

34.2. The contractor shall estimare net cost per hectare.

ARTICLE 35.- ADDITIONS TO THE PRESENT CONTRACT.-

Any modifications to the contract during its course of execution shall be made by codicil or rider which shall be agreed by both parties.

ARTICLE 36 - SUPPLEMENTARY ANALYSES CLASS FOUR.-

36.I. As mentioned in ANNEX III, the contractor is permited, during the course of the contract and once per year, to submit to the agreement of the administration a list of analyses class 4 to be done in definite soil and water samples, according to local difficulties and problems ancountered during the prospection; the inspector of the administration shall attach to that list his own opinion, favourable or unfavourable, after discussions with responsible pedologists.

36.2. This application of the contractor will be valid only under the condition which he attaches to the contract, on the date of signing, the net cost of every analysis class 4 mentioned in ANNEX III.

36.3. If the administration agrees, a rider shall be made between both parties for these supplementary analyses.

ARTICLE 37 - SUPPLMENTARY PITS AND TRENCHES AND SUBSEQUENT ANALYSES.-

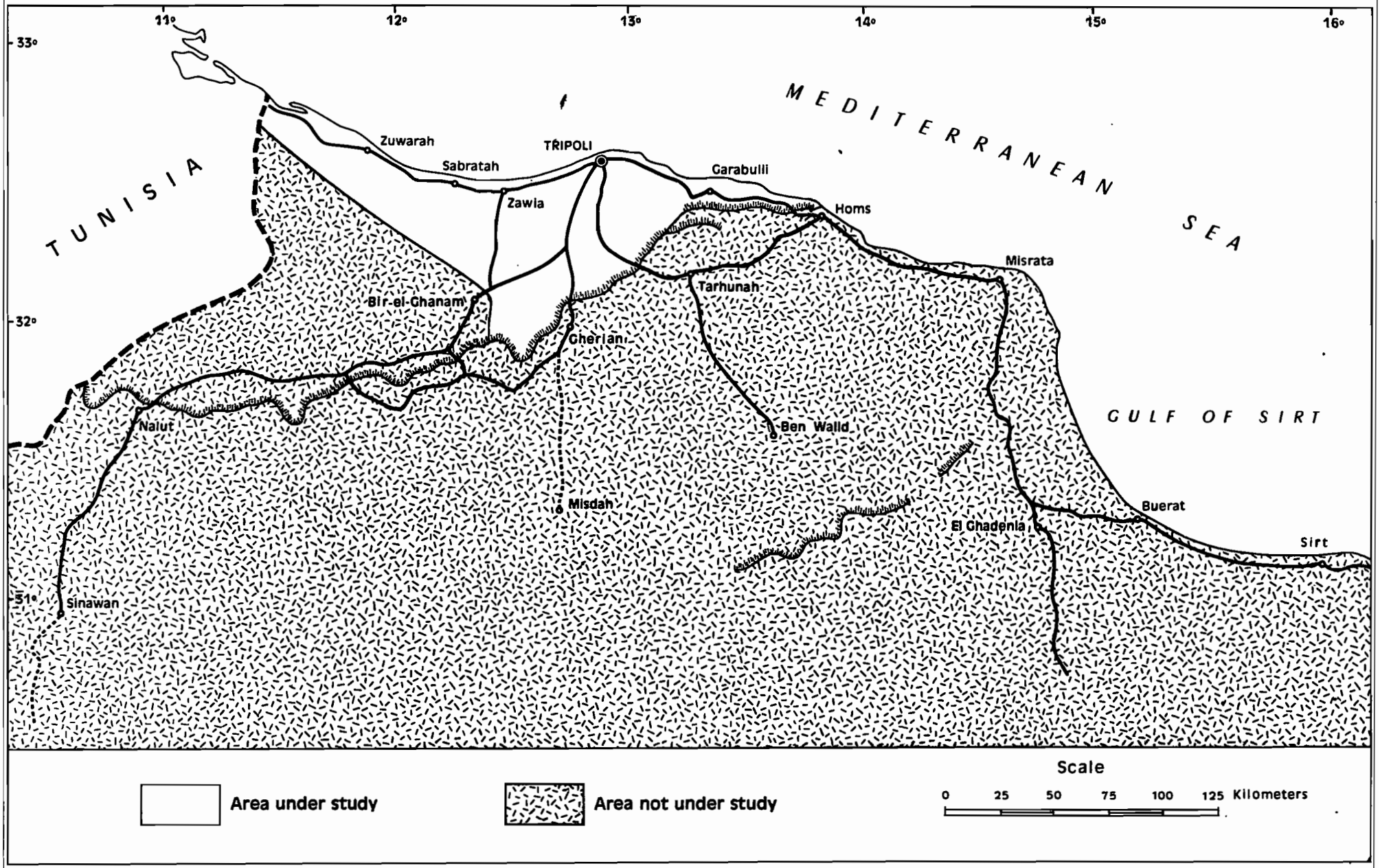
37.I. Once a year, during the course of his study on the site, according to difficulties encountered on the spot, specially to obtain the precision requested under ARTICLE 27, the contractor, as mentioned under ARTICLE 30, is permited to ask to the administration supplementary trenches in different depth and samples to be analysed (class 1, 2, 3), in way of a detailed list in giving his reasons; the inspector of the administration shall attach to that list his own opinion, favourable or unfavourable, after discussion with responsible pedologists.

37.2. This application of the contractor will be only valed under condition which he attaches to the contract, on the signing date :

net cost of trench (digging and describing) in various depth

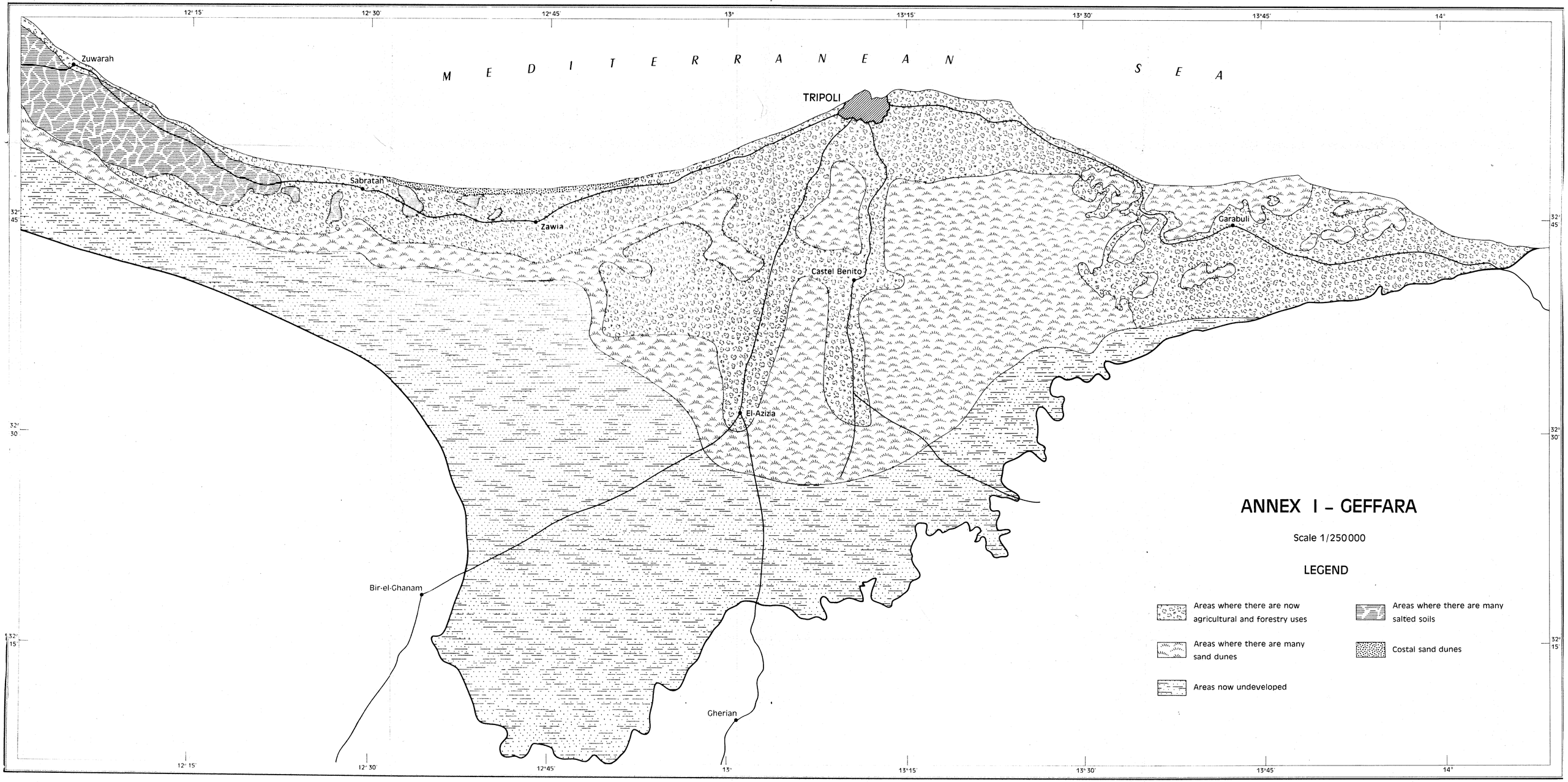
net cost of every kind of analysis

37.3. If the administration agrees, rider shall be made between both parties for that supplementary work.



ANNEX I - GEFFARA

PEDOLOGICAL STUDY to be made at a scale of 1/50000


12° 15'
12° 30'
12° 45'
13°
13° 15'
13° 30'
13° 45'
14°
M E D I T E R R A N E A N S E A
Zuwarah
TRIPOLI
Sabratah
Zawia
Garabuli
Castel Benito
El-Azizia
Bir-el-Ghanam
Gherian
32° 45
32° 30
32° 15
ANNEX I – GEFFARA
Scale 1/250000
LEGEND
Areas where there are now agricultural and forestry uses
Areas where there are many salted soils
Areas where there are many sand dunes
Costal sand dunes
Areas now undeveloped

PEDOLOGICAL SURVEY IN WEST MOUNTAINS (1)
AND DJEBEL NEFUSA (1)
TRIPOLITANIA (1)

Scale 1/50,000

PEDOLOGICAL SURVEY IN CYRENAICA (1)
Scale 1/50,000

TECHNICAL SECTION CHANGEABLE SECTION

ARTICLE 22 - EXPLANATORY STATEMENT.-

The Ministry of ..... through the services of Mr ..... contractor, and under the direction of Mr ..... inspector of the administration, has decided to make a study in the region covered by sheet N° ..... of the topographical map at scale of 1/50,000.

The total area to be studied is about :

..... sq-km in West Mountains - Tripolitania (1)

..... sq-km in Cyrenaica (1)

Soil studies should be made to define scientifical and practical characteristics of soils and their agricultural aptitude in order to use them in a modern way for agriculture, forest and grazing.

ARTICLE 23 - OBJECTIVE OF THE AGREEMENT.-

The semi-detailed study at the 1/50,000° scale of the soils in the region as defined under article 24 is the purpose of this agreement to entrust the contractor of doing so. The basic topographical documents will be the geographical map at the scale of 1/50,000 and aerial photographs at the scale of .....

ARTICLE 24 - DEMARCATION OF THE BOUNDARIES.-

24.I. In Tripolitania (1) the area to be studied is sutuated in West Mountains between (Kabow) and (Homs); it is indicated on the annexed maps in black ink showing its limits.

These maps, ANNEX I, woll serve as reference in case of any disputes.

(1) Score out unnecessary words.

In Cyrenaica (1) the area to be studied is situated in Djebel Al Akhdar (2), Djebel Al Iabal (2), Benghazi area (2); it is indicated on the annexed maps in black ink showing its limits.

These maps, ANNEX I, will serve as reference in case of any disputes.

ARTICLE 25 - GENERAL LINES OF THE STUDY.-

25.I. Scientifical objective

The contractor shall at first plan his work from scientifical point of view; towards this end, he shall make summarized study of climatology, vegetation and parent materiels of the area under consideration.

He shall study more accurately the following points :

- soil genesis and soil classification
- properties and agricultural value of various soils
- erosion problems under wind end water action and possible means to prevent soil erosion
- soil crust problems

25.2. Scientifical ability

As science of Pedology is developing continuously the contractor shall make every effort to apply the most up-to-date methods in analysing and classifying soils, as used by pedologists in general in the Mediterranean Basin and particularly in Maghreb; that, now and in the future, comparisons can be made of the experiments and results from countries having similar soils and problems.

For that purpose, he shall use the French soil classification and will give, when it is possible, the corresponding names in American Seventh Approximation.

He shall delineate soil units in the area under consideration, using the following system :

Soil class
Soil sub-class
Soil group
Soil sub-group
Family
Series (if possible)

(1) Score out unnecessary paragraph
(2) Score out unnecessary words

In the latter divisions, he shall use symbols to characterise the main features of soil texture.

25.3. Practical objective

According to the scientifical study and soil units previously delineated in this study, he shall try to obtain the most complete and possible information on the agronomical issues resulting therefrom.

Firstly he shall divide soils of the studied area in three main classes.

- Zone A where agricultural use is possible
- Zone B where some grazing or forest use is only possible
- Zone C where no cultivation or agricultural practice is possible, i.e. barren rocks.

Secondly : he shall study

- in Zones A :

irrigation and drainage possibilities

Danger due to erosion in cultivated lands and practical means to stop it

Promotion in agricultural uses

Possibilities of new crops and cultivation system

Adjustement of plants in various soils specially for orchards.

Reclamation of uncultivated lands

Fertilizers and manure needs

- in Zones B :

Possibility of forest improvement in order to have forest benefits and to stop erosion

Possibility of grazing according to danger of erosion

- in Zones C :

Nothing to be studied except preventing run-off

It is the duty of the contractor to make known and give his opinion regarding every problem encountered during the course of his study, even if it is not specifically mentioned in the contract.

25.4. Practical ability

The contractor shall furnish in his final documents, maps and reports, accurate information, in order to be directly used by the agronomists in charge of land improvement and reclamation.

For that purpose, the contractor shall employ the American classes System of land capability. But he must be careful that this system is not always well adapted to Mediterranean and desertic conditions.

He has latitude to make supplementary subdivisions in these classes, and he will refer to some symbols in maps to characterise particular soil-plant capabilities, irrigation and drainage possibilities, various land improvement and reclamation (cultivation, grazing, forest), work to be done, ... and any other duties he judges convenient and necessary.

ARTICLE 26 - PLAN OF STUDY.-

The contractor shall carry out the following operations, preferably in the order indicated below, although certain of them may be carried through during the whole course of the study.

26.I. Examination of existing documents.-

Topographical, climatical,geological, geomorphological, botanical.

He shall specially be careful to hydrogeology in order to be acquainted with underground waters.

He shall prepare a detai;ed bibliography of the studies and articles consulted and shall at ach such to his report : if necessary he will also indicate the areas where available documentation appears to be inadequate.

He shall also make synthesis of existing documents regarding soil and land use and verify their value on the spot, in order that they can be adapted to his own specifications

26.2. Aerial photographs.-

The contractor shall study cerefully aerial photographs both in the office and "in situ". At first, he shall try to note main features of the landscape, then to verify on the spot the corresponding soil units.

If it is considered necessary, he shall prepare a photoplan.

26.3. Preliminary study.

The administration and the contractor agree that during preliminary study, pedologists (or at least senior pedologists) may go well beyond the demarcation of the above mentioned boundary in order to allow the contractor to get familiar with the nature of the problems brought by the agriculture and the soils of the region over the whole bordering the section to be studied.

Such study will take about I5 days per year taking place at once or several times according to the necessity of the study.

26.4. Prospection of the site

He shall make study of the area delineated under Article 24 and Annex 1, observing natural cuts, digging trenches and pits, describing profiles and taking samples; he shall make an evaluation on the spot of the properties and characteristics of the soils according to article 25. He sha l be careful in studying specially soils where some agricultural and grazing practices are possible, and in making only cross sections in other soils.

He shall collect every information to him.

26.5. Analyses

He shall determine in laboratory the chemical and physical characteristics of the samples collected, according to the methods recommended in ANNEX III.

If in any exceptional case, he is using other methods, he should indicate his reasons and state most precisely the methods in way of bibliographical references.

He shall make in his report a brief reference of any method used in order to make them know by any reader.

The administration reserves the right, if necessary, to request supplementary analyses of certain samples, analyses which be filed and kept for a period of three years, then sent back to Libyan Soil Collection.

26.6. Final documents

He shall prepare synthesis of the elements gathered in way of a report with pedological land capability and erosion maps, as described in article 3I.

26.7. Fair copy

He shall prepare fair copy and make copies of these documents in the amoint requested by the administration (Article 33).

ARTICLE 27 - SUMMARIZING OF THE OBSERVATIONS MADE.-

27.I. Precision of the boundaries for each soil unit

This precision must be obtained by means of aerial photographs, pedological trenches and pits, auger-holes, etc ....

		From each side of the line	Total error
Zones A	Internal and external boundaries	± I25m	250m
Zones B	External boundaries	± I25m	250m
	Internal boundaries	± 200m	400m
Zones C	External boundaries	± I25m	250m
	Internal boundaries	± 500m	I000m

This statement of boundaries should be understood as margin of maximum error which never should be exceeded.

In fact, with an accurate use of aerial photographs, the average error on the counderies should generally be smaller.

27.2. Degree of uniformity

This degree of uniformity, which can be requested, is varying according to the different areas :

Zones A Degree of uniformity 80%

Zones B Degree of uniformity 70%

Zones C Degree of uniformity 50%

This degree of uniformity must be understood as percentage of correct caracteristical profiles in one soil unit.

If different soil units are very imbricated and their areas are too small to be set on maps at the scale of 1/50,000, the contractor shall define soil complexes and indicate them on his maps

27.3. Sketch map and drafts on the site

Towards this end, he shall make on the site sketch map and drafts summarizing all informations and shall indicate daily records for his own use. Such sketch map and drafts can be consulted by the inspector at any time.

ARTICLE 28 - NUMBER OF OBSERVED POINTS ON THE AREA UNDER STUDY.-

28.I. The contractor shall make study of the site, in depth, by means of natural cuts, auger-holes, pits and trenches.

Pits and trenches are at least I80 centimeters in depth, sizes in width and length sufficient enough for observing profile and taking samples in easy way. If a hard rocky level is encountered in soil, one stops to dig pit in depth.

28.2. The average number of trenches pits and auger-holes are as follows :

	area Hectare	Pits and trenches	Auger-holes
Zones A	200	8	0
Zones B	200	3	2
Zones C		0	0

According to the special conditions of the site, it is the proper job of the contractor to replace pit by auger-holes or inversely to locate his observed points in such places which suit his purpose provided that these average numbers are observed.

Such average numbers are available only for soils which can be put to practical use; they could be increased on the boundaries of pedological pedological units and in areas where these units are very imbricated as mentioned under Article 30 and 36 when rocks (zones C) do exist, the pedological study shall be made by means of cross sections according to the information given by aerial photographs.

There shall be no pit or trench in rocks made by the contractor.

ARTICLE 29 - OBSERVING PROFILES AND TAKING SAMPLES.-

Soil profile of each trench (or pit) shall be observed each horizon studied from the top to the bottom indicating every information and detail available for the study, according to the specific way of the pedologist and the instruction given by ANNEX II.

Parent materials, if they are visible, shall be studied as soil horizon.

In case. there is water-table existing and visible, contractor must be careful about it, its possible variations and influences under soil conditions.

29.2. Sampled profile

Among trenches and pits under observation, contractor shall choose very characteristical profiles in each soil unit in order to take soil samples at the average ratio : one sampled profile out of eight.

He shall sample every soil horizon on its entire depth, including parent-material when it is soft.

The weight of each sample shall be comprised approximately from half (1/2) kilog to one (1) kilog. The number of samples is very changeable in quantity from one profile to another, but the average amount should be about four (4) per profile.

29.3. Average number of sampled profiles and samples per hectare.

According to the paragraphs 28.2., 29.I and 29.2, the number of sampled profiles and samples, in areas where agricultural, forest and grazing purposes are possible, should be approximately as follows :

	Average number of		
	Hectares	Sampled profiles	Samples
Zones A	200	1	4
Zones B	500	1	4

In rocky soils, the contractor is permitted to take a few samples only in order to characterise these soils and their influence in other soils located below them.

29.4. Water-samples

The contractor shall take water-samples in some springs or wells when their water is used or available for irrigation, in order to have some information on their irrigation properties.

When water-table is found in trench (or pit), he shall take one water-sample.

ARTICLE 30 - ACHIEVED PRECISION AND SUBSEQUENT AGREEMENT.-

30.I. Towards the end of his study on the site, the contractor shall indicate if, in his opinion, the required degree of precision has been achieved.

If not, he should estimate the degree which has been reached and should explain the reason to the inspector of administration in writing.

30.2. Regarding latter case, with the agreement of the inspector, he may ask to the administration to make supplementary trenches, pits, auger-holes and soil analyses; this supplementary work shall be paid to the contractor under the basis of trench cost (including : digging, observing, eventually sampling) and cost of analyses agreed by both parties on the signing date of the contract (Article 37).

If this is accepted by the administration, rider will be added to the contract.

ARTICLE 3I - PRESENTATION OF FINAL DOCUMENTS.-

According to the aim and purpose of the contract and especially to the article 25, the contractor should hand over, every year during his study, the following documents :

3I.I. Report including :

- indications of natural surroundings : climatology, geology, vegetation, cultivated plants.
- synthesis of hydrological and hydrogeological information regarding above surface and underground water and possible use for irrigation.
- commentary developed from pedological map and its explanatory comments, with supplementary information impossible to be put on map.
- morphological description showing, for each soil unit, typical profile and its analytical data.
- information and some water-analyses about quality of water available for irrigation and rough estimation of possible evolution in soils under the condition of irrigation.
- commentary developed from the land capability map and its explanatory notes, with practical recommendations for each soil unit : capability of irrigation, possibilities of improvement of actual land use and introduction of new crops, soil-plant adaptation especially for orchards, use of necessary fertilizers, etc ...

He shall also indicate if, in his opinion, new cultivation system is desirable and agricultural experiments useful for that purpose.

In uncultivated land, he shall study possible land reclamation for agriculture, forest, grazing and work to be done.

- commentary of erosion map, with suggestion in remedying present situation and avoiding danger of erosion on the future. He shall also indicate works to be done for that purpose.

If existing data are used, firstly : the contractor must mention their origin briefly indicated in report, secondly in the bibliography in way of references.

3I.2. Pedological map (printed in different colours) at scale of 1/50,000 showing various soil units,in accordance with the instructions in article 25; this map must include location and number of profiles examined and sampled.

If it is not possible, another map showing profile location and number shall be made in way of an overlay.

3I.3. Land capability map (printed in different colours) at scale of 1/50,000, showing types of soil which can be given same treatment to put them into the same effective use according to the instruction of article 25.

This map must show the delineation of zones A, B, C;

It must be very detailed in zones A, less detailed in zones B and not at all detailed in zones C. Symbols and surcharges must indicate in the same land class main crops and cultivation system advisable, irrigation possibilith and work to be done, and every other detail which is considered to be necessary by the contractor.

3I.4. Erosion map (printed in different colours) at scale of 1/50,000 showing main forms of erosion by different areas and soil units : sheet erosion, furrow erosion, gully erosion, rain off and wind action and means for remedying and preventing them.

3I.5. Soil index cards

One for each described and analysed profile, showing on one side soil description according to ANNEX II and on reverse side soil analyses of samples collected from that profile.

3I.6. the contractor shall hand over, on the spot, during the whole course of the ground prospection, a sketch map and soil card drafts for daily records.

These grounds drafts and map may be consulted by the inspector at his own request at any time.

3I.7. Preliminary draft

The administration may request a preliminary draft under the condition by advising the contractor two months in advance or at the date of signing contract.

ARTICLE 32 - NUMBER OF COPIES.-

The administration shall then demand the number of copies to be submited by the contractor every year during his study, preferable includi including study of entire sheets of the topographical map at scale of L/50,000.

	Number of copies	
	Local use *	Local use and scientifical publication *
Report	I5	400
Pedological map	I5	400
Land capability map	I5	400
Erosion map	I5	400
Soil index cards	5	5

(* On the signing date the administration shall determine whzt use is intends to ma e with the documents, and will indicate the number of copies, scoring out the unnecessary column.)

ARTICLE 33 - TIME SCHEDULE.-

33.I. The administration shall undertake to inform contractor regarding all technical information on its disposal in particular :

- precise delineation in boundary limits of area under study
- climatical and hydrogeological information
- topographical maps of site * (L)
- aerial photos of site * (1)

Within ..... (time limit), after signature of the contract.

33.2. The contractor shall undertake to complete the study and to submit every final documents with a period of ..... years.

In case of delay, he shall be fined acccrding to Libyan Law, unless such delay is caused by "force majeure" or by incident beyond his control.

33.3. In prospecting site and preparing final documents, the contractor should preferably observe the following time limits within a period of one year.

(1) Except if the contractor is managing to obtain topographical maps and aerial photographs according to codicil agreed by both parties.

	Month
Preparatory work at office (aerial photographs survey bibliographical information general planning)	2
Preparatory work on site	1
Prospection on site	5
Preparation of drafts, analyses, copying of reports and maps	3

* At the end of each year, final documents will be submited to the administration.

33.4. ** the administration is defining priorities which are to be observed each year by the contractor as follows :

(establish convenient priorities just before tender announce date)

ARTICLE 34 - PRESENTATION OF ACCOUNTS.-

34.I. The contractor shall submit his estimate of expenses as follows :

	Amount
- salary of engineers and technicians of his company, including period required for preparation of study and period necessary to final report map and analyses as mentioned under article 26	.....
- aerial photographs and topographical maps (of they are not given by administration	.....
- vehicles and their maintenance	.....
- materials	.....
- salary of local employees	.....
- soil and water analyses	.....
- preparation of reports, printing of maps	.....
- copying of ducuments	.....
Total	.....

34.2. The contractor shall estimate net cost per each hectare in zones A, B and C.

ARTICLE 35 - ADDITIONS TO THE PRESENT CONTRACT.-

Any modifications to the contract during its course of execution shall be made by codicil or rider which shall be agreed by both parties.

* Line to be scored out if the study does not exceed one year.

** Paragraph to be scored out if the study does not exceed one year.

ARTICLE 36 - SUPPLEMENTARY ANALYSES CLASS FOUR.-

36.I. As mentioned in ANNEX III and Article 30, the contractor is permited, during the course of the contract and once a year, ta submit to the agreement of the administration a list of analyses class 4, to be done in definite soil and water samples, according to local difficulties and problems encountered during the prospection; the inspector of the administration shall attach to that list his own opinion in writing, favourable or unfavourable, after discussions with responsible parties.

36.2 This application of the contractor will be valid only under condition which he attaches to the contract, on the date of signing, the net cost of every analysis class 4 mentioned in ANNEX III.

36.3. If the administration agrees, rider shall be made between both parties for these supplementary analyses.

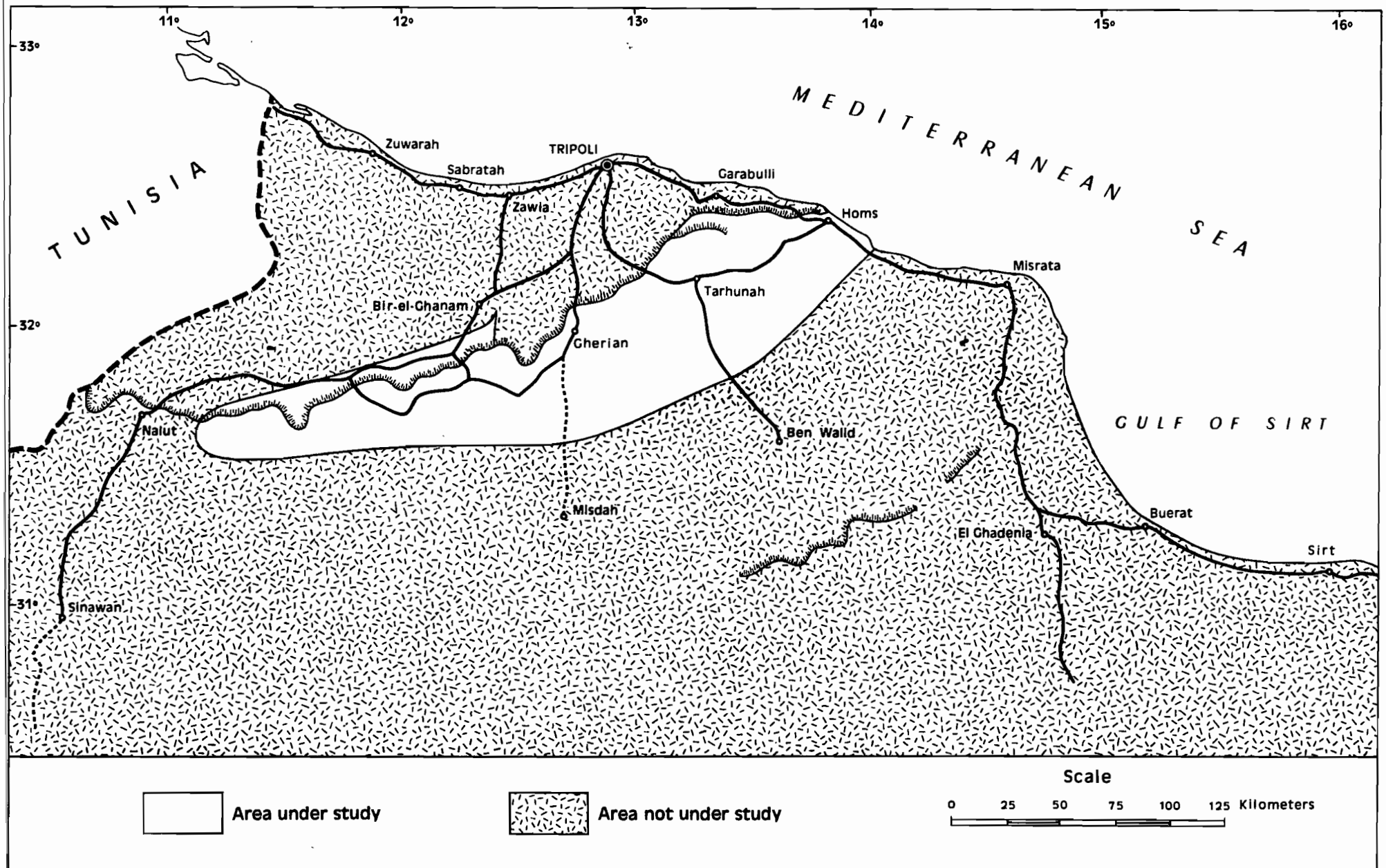
ARTICLE 37 - SUPPLEMENTARY PITS, TRENCHES AND SUBSEQUENT ANALYSES.-

37.I. Yearly during the course of his study on the site, according to difficulties encountered on the spot, specially in obtaining precision requested under ARTICLE 27, the contractor, as mentioned under ARTICLE 30, is permited to demand of the administration supplementary pits or trenches in various depth and subsequent samples to be analysed (class 1, 2, 3), in way of a detailed list in giving his reasons; the inspector of the administration shall attach to that list his own opinion in writing, favourable or unfavourable, after discussions with responsible parties.

37.2. The application of the contractor will only be valid under the condition which he attaches to the contract, on the signing date:

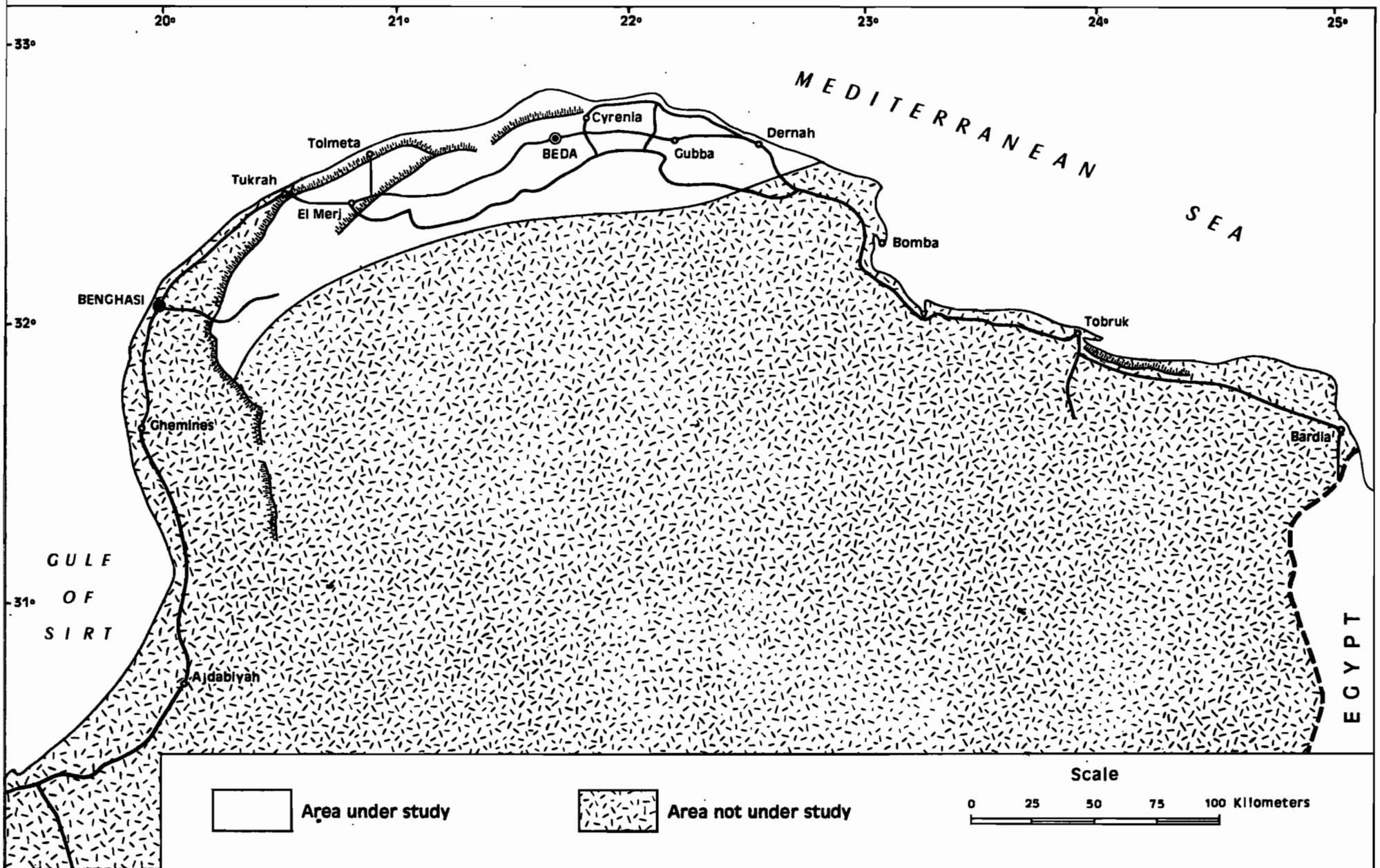
- net cost of trench (digging and describing) in various depth
- net cost of every kind of analysis

37.3. If the administration agrees, rider shall be made between both parties for that supplementary work.



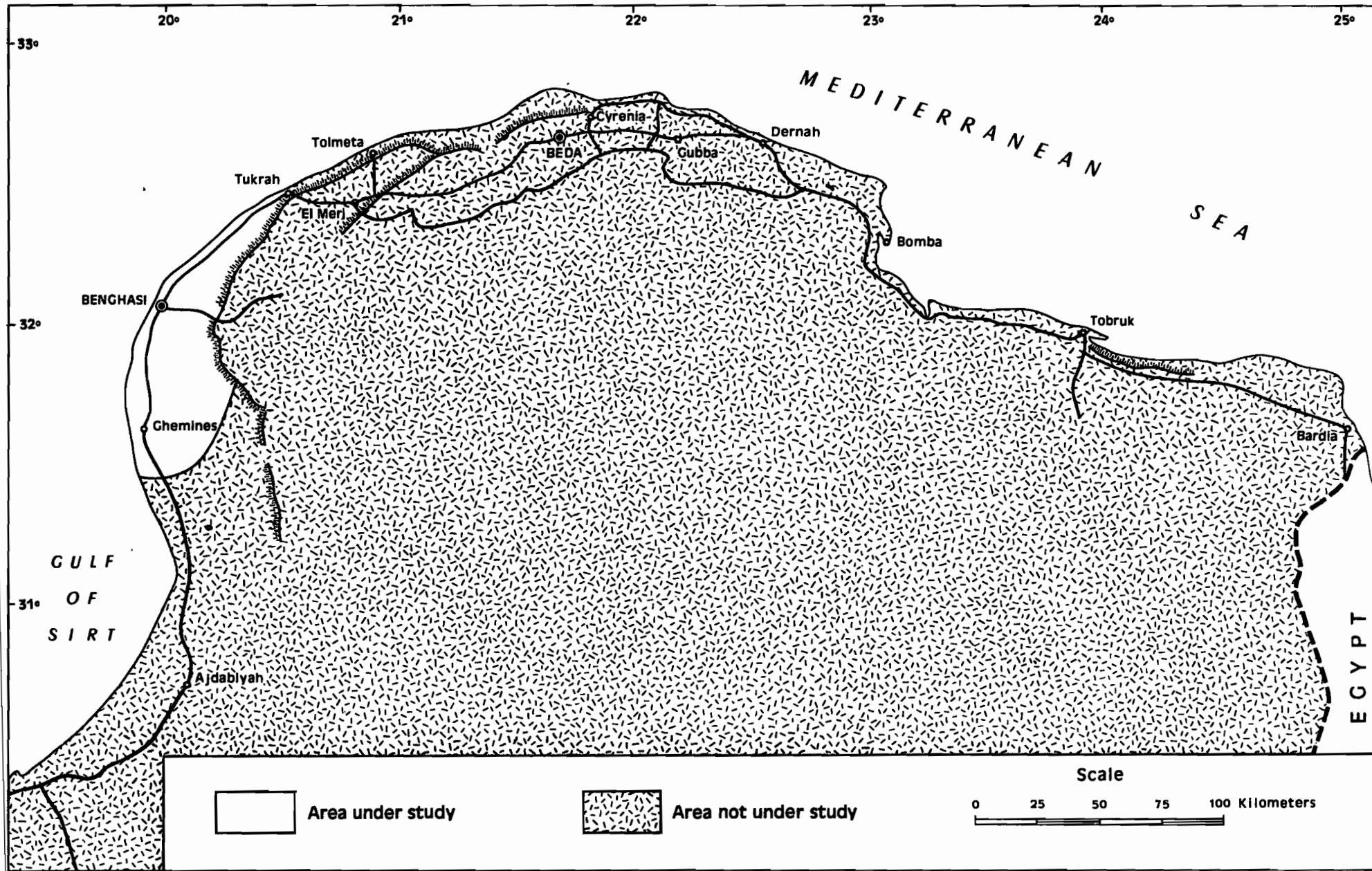
ANNEX I – WEST MOUNTAINS

PEDOLOGICAL STUDY to be made at a scale of 1/50000



ANNEX I – CYRENAICA

PEDOLOGICAL STUDY to be made at a scale of 1/50000



ANNEX I – BENGHASI AREA

PEDOLOGICAL STUDY to be made at a scale of 1/50000

TENDER DOCUMENT

TECHNICAL SECTION

OASIS

PEDOLOGICAL SURVEY

Scale 1/5,000° and 1/I0,000°

ARTICLE 22 - EXPLANATORY STATEMENT.-

The ministry of ..... through the services of Mr ..... contractor and under the direction of Mr ....., inspector, has decided to make a study in the Oasis named ..... and of its immediate surroundings.

The total areas to be studied content..... sq-km. Soil studies should be made to define scientifical and practical characteristics of soils and their agricultural aptitudes in order to use them for a modern farming husbandry.

ARTICLE 23 - OBJECTIVE OF THE AGREEMENT.-

The object of this agreement is therefore to entrust the contractor the detailed study at the 1/I0.000*-I/5.000* scale of soils of the region as defined under article 24.

ARTICLE 24 - DEMARCATION OF THE BOUNDARIES.-

24.I. The area to be studied is situated in the province of .....; it is limited on a map annexed by well indicated black lines. This map - ANNEX I - will serve as reference in case of any dispute.

24.2. The area to be studied shall be divided in two zones as follows :

Zone 1 - Oasis : actually cultivated and irrigated.

Zone 2 - adjacent surroundings, now uncultivated, but to be studied for future extensions of the oasis.

ARTICLE 25 - GENERAL LINES OF THE STUDY.-

25.I. SCIENTIFICAL OBJECTIVE . The contractor shall plan his work at first from a scientifical point of view; towards this end, he shall make summary studies of the vegetation, climatology and parent materials of the area under consideration.

He especially shall study influences of the water table level on oasis soil (zone 1) : hydromorphy, salinity, encrustement, etc ...

* Score out unnecessary number.

For that purpose, he will try at first to delineate the three classical parts of every oasis :

upper part of the oasis : where soils are sane and generally weakly developped.

middle part of the oasis : where hydromorphy is appearing in rather weakly developped soils

lower part of the oasis : where hydromorphy gives to soils their main characteristics.

He shall study the importance of water-table about soil genesis, specially in incrustation, thick cimented layers (limestone and gypsum), salinity, gley horizon.

He will give his opinion on the possible modifications in soil in case of any change on water-table level.

In the surroundings (zone 2), he shall study various desertic soils and their possible modifications under irrigation and cultivation.

It is the duty of the contractor to make known every problem encoun encountered during the course of his study, even if it is not specifically mentionned in the contract, to give his opinion.

25.2. SCIENTIFICAL ABILITY.

As pedology is a continuously developing science, the contractor shall make effort to apply the most up-to date methods in analysing and classifying of soils as used by pedologists in the Mediterranean basin in general and in the Maghreb in particular; that, now and in the future, comparisons can be made of the experiences and results from countries having similar soils and similar problems. For that purpose, he shall use the French soil classification and will give, if possible, the corresponding names in American Seventh Approximation.

He shall delineate soil units in the area under study using French soil classification and separating soils at first into :

- weakly developed soils
- hydromorphic soils
- saline and alcaline soils

then using the following subdivisions:

Soil group
Soil sub-group
Family
Series
Type
Phase

He should specially mention texture in soil types and influence of erosion (even weak), cultivation, vegetation, irrigation and drainage in soil phases.
He shall note every information collected about the evolution of the water table.

25.3.- PRACTICAL OBJECTIVE.

According to the scientifical study (pedological map and report) ,and soil units delineated by this study, the contractor shall define very precisely soil capabilities for agricultural purpose. In zone 1 he shall study :

- qualities and deficiencies of irrigation and drainage actual system
- qualities and deficiencies of actual land use and cultivation system
- possibilities of changes in the cultivating system and introducing new crops.

In zone 2 he shall delineate :

- area unsuited for agricultural purposes
- area where it is possible to extend the oasis (in case of sufficient availability of water supply all year round)
- area where it is possible to have irrigated winter barley crops or winter fodder plants, when water supply is available only in winter.

In case of saline and alkaline soil, he shall study the actual adaptation of crops to salted soil conditions of this oasis.

25.4.- PRACTICAL ABILITY

a) In studying land capability problems, the contractor shall request advices and opinions of other experts, particularly :
Bioclimatologist : for problems of introduction of new crops or new variety of plants already cultivated in oasis :
- vegetables of every quality for exportation and local trade
- Dates of the quality requested for exportation
- Citrus trees
- and every other crop that he recommends.

Experts in Agronomy and irrigation for problems of cultivation system :

- Irrigation and calculated amount of irrigation water supply for each irrigation dose
- Drainage and approximate intervals between two drainage-pipes and ditches
- Density optimum for palm trees in single cultivation or with other crops
- Natural manure and fertilizers
- Changes in cultivation system.

The contractor shall furnish in his final documents, maps and report, information accurate enough so that they can be directly used by the agronomists in charge of land improvement and reclamation.

b) For that purpose, the contractor shall use the American Classes System of Land Capability.

But he must be careful that this system is not always well adapted to mediterranean and desertic conditions.

He has latitude to make supplementary subdivisions in these classes. He will use symbols to characterise particularly soil-plant capabilities, works to be done, land improvement, different grades in irrigation and in drainage, etc .....

ARTICLE 26 - PLAN OF STUDY.-

The contractor shall carry out the following operations, preferably in the order quoted below, although certain of them may be carried through during the whole course of the study.

26.I. Examination of existing documents : topographical, geological, geomorphological, hydrological, pedological, phytosociological, agronomic.

He shall prepare a detailed bibliography of the work studies and articles used, and shall attach such to his report. When necessary, he will also indicate the areas where documentation available appears to be inadequate. These informations must help the contractor but shall never serve as a substitute for his proper work.

26.2. Aerial photographs : the contractor shall study carefully aerial photographs both at the office and "in situ". If it is necessary and possible, he shall change the scale, by means of new photographs, in order to have documents at the scale requested.

He can use these aerial photographs as substitute for topographic maps when these maps are too old or too vague.

If it is considered necessary, he shall prepare a photo plan.

26.3. Preliminary study : the administration and the contractor agree that during a preliminary study, pedologists (or at least senior pedologists) will visit other oases beyond the oases under study, in order to allow them to get acquainted with nature of the problems of the oases soil and agriculture.

Such a study will take about I5 days, taking place at once or several times according to the necessity of the study.

26.4. Prospection of the site : he shall make a study of the area, observing natural cuts, digging trenches and pits, describing profiles, and taking samples.

He shall make an evaluation on the spot of the properties and characteristics of the soil according to article 25.

He shall collect every information helpful to him.

26.5. Analyses : he shall determine in laboratory the chemical and physical characteristics of the samples collected, according to the methods recommended in ANNEX III.

If, in exceptional cases, he is using other methods, he should indicate his reasons and state most precisely the methods in way of bibliographic references.

He shall note in his report a brief reference on every method used to make them known by any reader.

The administration reserves the right, when necessary, to request supplementary analyses of certain samples, analyses which can be incorporated by means of a rider; for this reason these samples should be filed and kept for a period of three years.

26.6. Final documents : he shall prepare a synthesis of the elements gathered together in way of a report with pedological map and land capability map.

26.7. He shall make a fair copy and make copies of these documents in the amount requested by the administration.

ARTICLE 27 - SUMMARIZING OF THE OBSERVATION MADE.

27.I. Precision of the boundaries for each soil unit. This precision must be obtained by means of aerial photos, pedological trenches and pits, auger holes.

			From each side of the line	Total error
* I/I0,000	zone I	(oasis)	± I5 m	30m
* 1/5,000	zone 1	(oasis)	± I0 m	20m
** 1/I0,000 or 1/5,000	zone 2	(surrounding area)	± 40 m	80m

when there is intergrade between two soils units, the contractor shall mention it on the map, if it is possible, and in his report.
The statement of boundaries quoted above should be understood by the contractor as indicating a margin of maximum error which never should be exceeded. In fact the average error on the boundaries would be generally smaller.

27.2. Degree of uniformity

Zone 1 (oasis) Degree of uniformity 95%

Zone 2 (surrounding area) Degree of uniformity ..... 80%.

27.3. Determination of the useful characteristics of the various horizons of each soil unit :such estimation is necessary in detailed studies in order to determine hydrodynamic characteristics for irrigation.
For every unit of soil, the contractor shall indicate soil permeability, available moisture and wilting point in each horizon.
He will calculate their average value and the variation of different numbers from each side of the average number.
If this variability is too large (for instance60% in soil permeability), efforts to make subdivisions in the units of soil should be made.

ARTICLE 28 - NUMBER OF OBSERVATION POINTS ON THE AREA UNDER STUDY.

28.I. The contractor shall make a study of the site in depth by means of natural cuts, auger-holes, pits and trenches.
Pits and trenches are at least I80 centimeters in depth with sizes in breadth and length sufficient enough for observing profiles and taking samples in easy way. When a hard rocky level in encountered in soil, one stops to dig the pit in depth.

* Score out unnecessary line.

28.2. The average number of trenches, pits, and auger-holes shall be the following, according to the precision rate requested in Article 27

* Scale 1/10,000	area-Ha	Trenches Pits	Auger-Hole
Zone 1 (oasis)	per 6 Ha	2	1
Zone 2 (surrounding area)	per 10 Ha	1	2

* Scale 1/5,000	area-Ha	Trenches Pits	Auger-Hole
Zone 1 (oasis)	per 2 Ha	1	1
Zone 2 (surrounding area)	per 10 Ha	1	2

* Score out the unnecessary table

It is the proper job of the contractor to locate his observed points in such places which suit his purpose (provided that these average numbers are observed) and to replace auger-holes by trenches if it is necessary. In particular, in the surrounding area (zone 2), he at first shall make effort to delineate by means of aerial photographs and cross sections rocky and crusted zones (calcareous or gypseous) and very saline areas which only need one pit per soil unit.
Auger-holes will be preferably concentrated on soil bounderies in order to precise them accurately.

ARTICLE 29 - OBSERVING PROFILE AND TAKING SAMPLES.

29.1. Soil Profile of each trench (or pit) shall be observed and studied horizon per horizon up to down, noticing every information and detail available for the study, according to the special way of the pedologist and the instruction given by ANNEX II.
Parent material , when it is visible, shall be studied as soil horizon.
Contractor shall be specially careful to water-table, its possible variations and its influence on soil condition.

29.2. Sampled Profile : among trenches and pits under observation, contractor shall choose very characteristics profiles in each soil unit in order to take soil samples, at the average ratio of one main profile per six profiles.

He shall sample every soil horizon on its entire depth, including parent material when it is soft.

The weight of each soil sample shall be comprised approximatively between 500gr and one kilo.

The number of samples is very changeable from one profile to another but the average amount of samples should be 4 per profile.

29.3. Average number of sampled profiles and samples per Hectare.

According to the paragraphs 28.2. and 29.I., the average number of sampled profiles and samples should be approximately as following :

* Scale 1/I0,000	average number of		
	Hectares	Sampled profile	Samples
Zone 1 (oasis)	I8-20	1	4
Zone 2 (surrounding area)	60(1)	1	4

(1) In crusted, saline and rocky areas, contractor is only permitted to get samples on one profile per main kind of saline soil and crust and one (or two) sample in each main kinds of altered rocks.

* Scale 1/5,000	average number of		
	Hectares	Sampled profile	Samples
Zone 1 (oasis)	I0-I2	1	4
Zone 2 (surrounding area)	60(1)	1	4

(1) In crusted, saline and rocky areas, contractor is only permitted to get samples on one profile per main kind of crust and saline soil and one (or two) sample in each main kinds of altered rocks.

* Score out unnecessary table.

29.4. Water-table surveying and water samples. Every two months, during the work on the site, the contractor shall take water samples at the rate of :

2 samples per spring or well used for irrigation

2 samples in main drainage sewers

when water-table is found in a pit, he shall note exactly its depth and shall take a water-sample at the same time that soil samples. In his final check-up (on a period shorter than one week), he shall note exactly once more water-table depth and take water samples in every pit where it is found, in order to make a map showing water-table level in the oasis at that time.

ARTICLE 30 - ACHIEVED PRECISION AND SUBSEQUENT AGREEMENT.

30.I. Towards the end of his study on the spot, the contractor should indicate if, in his opinion, the required regree of precision has been achieved. If not, he should estimate the degree which has been reached and should explain the reason in writing to the inspector.

30.2. In this latter case, with the agreement of the inspector, he mays ask to the administration to make supplementary trenches, pits, or auger-holes and sample analyses ; this supplementary work shall be paid to the contractor on the basis of trench cost (all included digging, observing, and eventually sampling) agreed by both parties on the signing of the contract (ARTICLE 36 and 37).

If administration accepts, rider will be added to the contract.

ARTICLE 3I - PRESENTATION OF FINAL DOCUMENTS.

According to the aim and purpose of the contract and specially to the article 25, the contractor should hand over, at the end of his study, the following documents :

3I.I. A report comprising

- indications of the natural surroundings : geology, vegetation, cultivation

- synthesis of climatical information gathered in the oasis under study, synthesis detailed enough to help bioclimatologist and agronomist in their work

- commentary developed from the pedological map and its explanation, with supplementary informations which are not conveniently placed on the map,

- morphological description throwing up for each soil unit typical profile and its analytical data

- information and analysis about quality of irrigation water and of water-table

- opinion about influence in soil of water-table and its possible changes in modifying water-table level by irrigation and drainage

- commentary on the land capability map and its explanatory notes with practical recommendations for each unit of soil : capability of irrigation, of drainage, work to be carried out, improvement of actual land use, possibility of new crops; necessity of fertilizers and manure. In zone 2, he shall insist on possible extension of cultivated area either in way of typical oasis or in way of winter cultivation (barley and fodder-plant).

- a commentary on the erosion problems and on the defence against mobile sands.

3I.2. Pedological map (printed in different colours) at a scale of 1/10,000*, 1/5,000*, showing various soil units in accordance with the instructions of article 25; this map must include location and number of profiles examined and sampled.

3I.3. Land capability map (printed in different colours), at a scale of 1/10,000*, 1/5,000*, set forth from pedological map, showing soils to which can be given the same way of treatment to put them into the same effective use : irrigation and drainage practices, agricultural improvement, possibility of changes in land use and of introduction of new crops.

On the limits of the oasis and in the areas surrounding it, this map shall point various zones either suitable for cultivation or unuseful for agricultural purpose.

Symbols and legend shall indicate on this map various works to be done (defence against mobile sands and erosion , drainage ditches, land levelling, etc ...) and main agricultural improvement (available irrigation water supply, date-tree clearing, new crops possible, etc ...).

3I.4. A map showing water table depth and salinity with mention of the period of its observation.

3I.5. Soil index cards, one for each profile described, sampled and analysed showing on one side soil description in accordance with ANNEX II, on the reverse side soil analyses (when samples are analysed).

* Score out unnecessary scale.

3I.6. The contractor shall hand over during the whole course of his work on the spot sketch map and draft soil cards which should be entered every day for his own purpose.

Those ground-drafts may be consulted by the inspector on his own request.

3I.7. The administration may request a preliminary draft, on the condition that they advise the contractor two months in advance or at the date of the contract signing.

ARTICLE 32 - NUMBER OF COPIES.-

The administration shall than fix the number of copies to be submitted at the end of study.

	Number
Report	I5
Pedological map	I5
Land capability map	I5
Water table depth and salinity * map	I5
Soil index cards	5

ARTICLE 33 - TIME SCHEDULE

33.I. The administration shall undertake to give to the contractor all technical information at its disposal, and in particular :

- precise delimitation of boundaries of the area under study
- climatical and hydrogeological data
- topographical maps of the site
- aerial photographs of the site

within ..... (time limit), after signature of the contract.

33.2. The contractor shall undertake to complete the study and to submit the final documents within ..... (time limit).

In case of delay, he shall be fined according to Libyan Law, unless such delay is caused by "force majeure", or by events beyond his control.

The following time limits should be preferably observed during the course of the study

Preparatory work at office	..... Month
Preliminary study beyond site	.....
Prospection on site	..... Month
Preparation of reports, maps, analysis and copying of documents	.....

* If salinity is considered to be studied according to local conditions.

ARTICLE 34 - PRESENTATION OF ACCOUNTS.-

34.I. The contractor shall submit his estimate of expenses as follows :

	Amount
- salary of engineers and technicians of his company, including period required for preparation of study and for period of preparation of final report as mentioned under article 26	.....
- Aerial photographs	.....
- Vehicles and their maintenance	.....
--Materials	.....
- Salary of local employees	.....
- Analyses	.....
- Preparation of reports, printing of maps	.....
- Copying of documents	.....
TOTAL	.....

34.2. The contractor shall estimate net cost per hectare in zone 1 and 2

	Net cost per Hectare
Zone 1 (oasis)	.....
Zone 2 (surrounding area)	.....

ARTICLE 35 - ADDITIONS TO THE PRESENT CONTRACT.

Any modifications to the contract during its course of execution shall be made by codicils which shall be agreed by both parties.

ARTICLE 36 - SUPPLEMENTARY ANALYSES.-

36.I. As mentioned in ANNEX III, the contractor is permitted to submit during the course of the contract to the agreement of the administration a list of class 4 analyses to be done in definite soil samples and water samples, according to local difficulties and problems encountered during the prospection; the administration inspector shall attach to that list his own opinion, favourable or unfavourable, after discussion with responsible pedologist.

36.2. This demand of the contractor will be valid only on condition that he attaches to the contract on the date of signature the net cost of each class 4 analyses (see ANNEX III).

36.3. If the administration agree, a rider shall be made between both parties for those supplementary analyses.

ARTICLE 37 - SUPPLEMENTARY PITS AND TRENCHES AND SUBSEQUENT ANALYSES.

37.I. During the course of his study on the site, according to difficulties encountered on the spot, specially to obtain the precision requested under Article 27, the contractor, as mentioned under article 30, is permited to ask to the administration supplementary trenches at different depth with soil samples to be analysed (class 1, 2, 3) in way of a detailed list his own opinion, favourable or unfavourable, after discussions, with responsible pedologists.

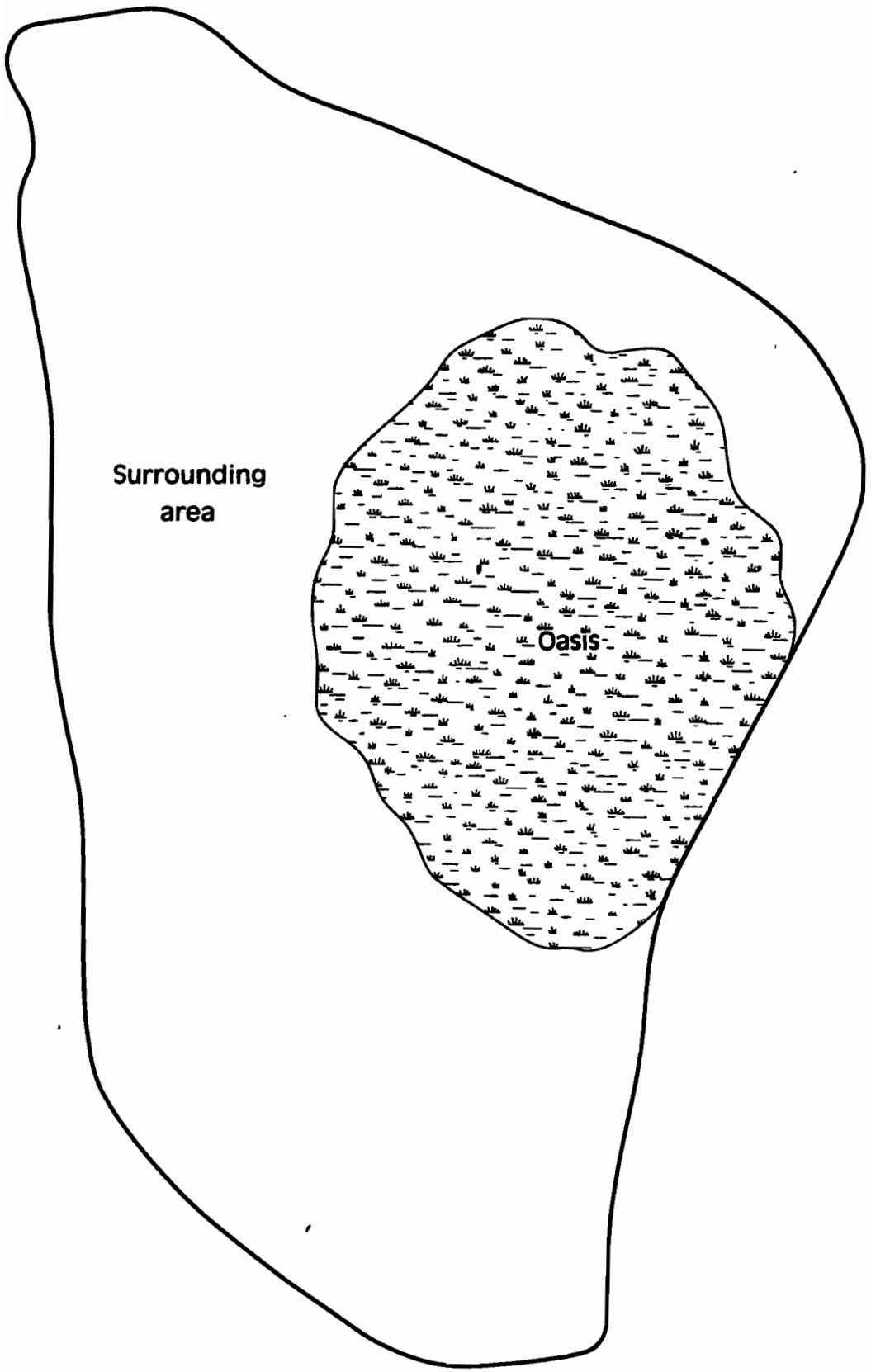
37.2. This application of the contractor will be only valid on condition that he attaches to the contract, on the signing date :

net cost of a trench (digging, describing at various depth and eventually sampling,

net cost of each kind of analysis.

37.3. If the application is accepted by the administration, a rider shall be made between both parties for that supplementary work.

ANNEX I – OASIS



Sketch map quoted here as an example to be adapted for each oasis

ANNEXE II

PROFILE DESCRIPTION

PERIMETER No. PIT NUMBER

OBSERVER

DATE

LOCATION

TOPOGRAPHY ..... (slope) ....., (valley)....., (plateau)....

EROSION ..... kind od erosion ..... strong, medium, weak

DEGREE OF THE SLOPES % (estimate)

GEOLOGY

PARENT MATERIAL

VEGETATION Kind (Forest), (Brush), (Steppe), (Cultivated), (Plants)

Plant names (if possible vernacular and latin names)

DEPTH OF THE PIT ..... Meter and centimeters .....

ACTUAL LAND USE (orchard) (culture) .... (fallow) (irrigation) (dry-farming), (grazing) .....

WATER TABLE ..... (depth, salinity ...etc.....)

THICKNESS	HORIZON I	HORIZON 2	HORIZON 3	HORIZON 4	PARENT MATERIAL
COLOR (with mun-sell color chart)					
Organiz Matter					
Texture (estimate)					
STRUCTURE main structure medium structure sub-structure					
Presence of plant roots					
Humidity					
Pebble					
Lime (with HCl)					
Other remarks crust, gypsum. etc ...					

Soil classification .....

Land capability .....

ANNEX III

Soil and Water analyses

I - Soil analyses.

Soil samples, air dried, are sifted in a 2 millimeter sieve in order to keep apart gravel and stones and analysis are to be made on fine soil. Such analyses are divided in four classes :

Class 1 Soil analyses to be made on every sampled profile and

Class 2 Soil analyses to be made on every sampled profils, but only on every top samples down to 60-80 centimeter deep.

Class 3 Soil analyses to be made only on very characteristic profiles of soil units in order to have as many information as possible about its properties.

3.1. o be made on one sampled profile to five and on each sample of it.

3.2. To be made on one sampled profile to three but only on the top sample and one other chosen by pedologist.

3.3. (Water analyses) : to be made only on one sample to five.

Class 4 These analyses are used to elucidate local problems (scientifical or practical matters) arisen during the work on the spot; that is why it is impossible to fix their average number in advance.

According to the articles 36 of the tender document, pedologists may ask a rider for some of those analysis during the final phase of his ground survey.

The amount of such analysed profiles (fourth class analysis) should not exceed four profiles per main soils units.

Annex III

SOIL PHYSICS

Kind of analysis	Method and references	Class
Granulometry	Soil particles divided in following fractions (micron) : 0-2, 2-20, 20-50, 50-200, 200-2000 ROBINSON G.W. "Soils-their Origin-constitution and classification" 2th Edition I936, 442p, Thomas Murby Editor, London ROBINSON G.W. - Journal of Agric.Sc.I922, t. XII, p. 306 ROBINSON G.W. - Agric. Progress, Vol. V, I928 VANLANDE "Granulomètrie des terres gypseuses d'Algérie" C.R. Académie Agriculture T 39, n° 7, I958, Paris.	1
Soil Structure	HENIN S., MONNIER G., COMBEAU A. "Méthode pour l'étude de la stabilité structurale des sols", Annales Agronomiques, I958, 1, p. 7I-90, Paris.	3-2
Permeability	HENIN S. "Le profil cultural" Société Edition Ingénieurs Agricoles, I960, 320 .p. France	3-2 (1 in detailed survey 1/5000 1/I0,000)
Specific gravity	UNGERERR E., in "Klein Handbuck der Pflanzenalyse", I933, 3 and 4, J. Springer ed., Wien, GRADWELL M.W. "The determination of specific gravities of soil as influenced by clay mineral composition" N.Z.J., Sci. Techn., I955, 37I3, p. 283-289	4
Bulk density	BURGER H. "Mitt. eidg. Anst. f. d. forstl. Versuchsw, I922, XIII, 1 RUSSEL M.B. I949, Soil Science, 68, p. 25-35.	4
Atterberg Limits	RUSSEL J.C. WEHR F.M. "The Atterberg consistency constants" J. of Amer. Soc. Agron., I928, 20, 354-372.	4
Equivalent Moisture & Wilting point	RICHARDS L. "Methods ,of measuring soil moisture tension". Soil Science, I949, 68, pp. 95-II2. GRAS R. "Quelques observations sur les relations entre les propriétés physiques du sol et la croissance du Pêcher dans la vallée du Rhône entre Vienne et Valence". Annales Agronomiques, I3, I962, P. I4I. COMBEAU A., QUANTIN P. "Observations sur la capacité au champs de quelques sols feralitiques". Science du Sol n° I, Mai I963	2 (1 for detailed survey 1/5000, 1/I0000)
Moisture Profile	TAYLOR S.A. "Field determination of Soil Moisture" Agr. Eng., I965, 36, p. 654-659.	4
Equivalent Moisture	LEBEDEFF "Proceedings of 1th Intern. Congr. Soil Science" Washington I927, t.1, p.55I VAGELER - Journ. Agric. Science, I935, t XXV, p. 326.	4

Nitrogen	SOIL CHEMISTRY - Kjeldhal method	3-2
pH	Electrometric method with glass electrode (in distillated water and in KCl) BATES R.G. "Electrometric pH determination" I954, John Wiley and sons Ed. New-York SCHOFIELS R.K., TAYLOR A.W. "The measurement of soil pH" Soil Sci. Soc. Amer. Proc. I955, I9, p. I64-I67	1
Calcium carbonate (total CO_3Ca)	BRUNEL A. "Traité Pratique de Chimie Végétale" I948, tome 11, p. 342	1
Active calcium carbonate	DROUINEAU G. "Méthode rapide d'appréciation du pouvoir chlorosant des sols calcaires" Annales Agronomiques, I943, 1, p. I6-I8	- 3-1
Available phosphorus	OLSEN S.R., COLE C.V., WATANABLE F.S., DEAN L.A. "Estimation of available phosphorus in soil by extraction with Sodium carbonate" U.S. Department of Agriculture, circular n°939	2
Exchangeable Bases (1)	Except for saline and gypseous soils Ca, Na, Mg, K SCHOLLENBERGER C.I., SIMON R.H., "Determination of Exchange capacity and exchangeable bases in Soil-Ammonium Acetate Method" Soil Science, I945, Vol. 59, pp. I3-24.	
Total Bases (1)	Ca, Mg, Na, K PIPER C.S. "Soil and Plant Analysis", I947, Inter Science Publish, New-York	4
Soluble salts	Chiefly for ,saline and gypseous soils Conductivity, Ca, K, Na, Mg, SO_4, Cl, CO_3H UNITED STATES SALINITY LABORATORY STAFF "Diagnoses and improvement of saline and alkali soils" U.S. Department of Agriculture Handbuok N° 60 - I954	1
Trace Elements	"Methods of Soil Analysis" Part 2, Volume 9 of AGRONOMY. American Society of Agronomy Inc. publisher Madison, Wisconsin, U.S.A., I965 PINTA M. "Recherche et dosage des éléments traces" I962. Dunod Edit. Paris	4
Clay Mineral	Differential thermal analysis X-Rays Analysis CAILLERE S., HENIN S. "Minéralogie des Argiles", I963, Masson editor, Parcs GRIM R.E. "Clay Mineralogy" I953 Mac Graw-Hill Book Company Inc. Publisher New-York, London, Toronto MILLOT G. "Géologie des Argiles" I964, Masson Editor, Paris	4

	Class
RODIER J. "Analyse chimique et physico-chimique de l'Eau (Eaux naturelles et eaux usées)" 3ème Edition - DUNOD - PARIS I966	
Dried Salts (after filtration)	1
Resistivity (after filtration)	1
Cations and anions (after filtration) (Na, Ca, Mg, K, SO_4, Cl, CO_3H) (1)	1 for 1/5/000 and for 1/I0 000 3-0 for other scales

(1) N.B. - Cation Analysis for Ca, Mg, K, Na

Na and K must be determined by Photometry
Ca and Mg can be determined by two methods
- complexometry (EDTA Method)
- photometry only when the photometer is supplied with a system for atomic absorption

Photometry references

MAURODINEANU R., BOITEUX U. "L'analyse spectrale quantitative par la flamme" I954, Masson edit., Paris

MITCHELL R.L. "The Spectrographic Analyses of Plants, Soils and related Materials". Commonwealth Bureau of Soil Science, I948

PINTA M. "Application de Spectrographie de flamme et d'arc dans l'analyse agronomique" Annales Agronomiques, N° 2, pp. I89-202, I955

Complexometry references

FLASCHKA H.A. "E.T.A. Titrations" I959. Pergamon Press, London, New-York, Paris, Los Angelès

SIMONS E.L., NEWKIRK A.E., PRIBIL E. "Analytical Applications of E.D.T.A. and related compounds" Pergamon Press, London, New-York, Paris, Los Angeles

PEDOLOGIE. Symp. intern.3. Class. des Sols, pp. 25-56. Gand, 1965.

LA CLASSIFICATION PÉDOLOGIQUE UTILISÉE EN FRANCE*

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Etablir pour des objets naturels une classification, c'est constituer une série de catégories régulièrement et logiquement ordonnées dans lesquelles chacun d'eux puisse être placé.

Elle doit donc, en particulier, satisfaire au principe d'homologie et de subordination des caractères. Ceux permettant de définir ces catégories doivent être de même nature, à chacun des niveaux de la classification, et être choisis de façon à présenter, des niveaux supérieurs aux niveaux inférieurs, un degré de caractérisation croissante et de généralité décroissante. Par contre on ne peut exiger d'une classification pédologique que tout élément d'une catégorie soit plus semblable à tout autre élément de cette catégorie qu'à quelque élément que ce soit d'une autre. En effet, les « Unités Sols » ne peuvent être définies qu'arbitrairement, car elles forment un continu sur les plans génétique, morphologique et, à quelques exceptions près, géographique. Une telle classification doit donc être susceptible d'évolution pour tenir compte de modifications toujours possibles de ces limites, et d'accroissement pour permettre d'y intégrer des éléments nouvellement observés, ou des unités de catégories inférieures ou moyennes nécessaaires pour expliciter des éléments intermédiaires dont l'importance réelle dans la Nature aura été reconnue.

(*) Une publication provisoire, et un peu résumée, de la 1ère partie de ce texte a paru, dans les Cahiers de pédologie de l'O.R.S.T.O.M. 3 — 1963.

La classification pédologique doit être générale en ce sens qu'elle doit permettre de classer tous les sols existant à la surface du globe, ceux déjà reconnus et ceux qui pourront être observés dans les années à venir. Elle doit aussi être générale, en cet autre sens qu'elle doit pouvoir être utilisée comme élément de base des légendes des cartes pédologiques à quelque échelle qu'elles soient exécutées. A chacune correspond un niveau de la classification : à celle du millionième, les groupes, sous-groupes et quelques familles, au 1/100 000, déjà les principales séries. Bien entendu, toute légende de carte pédologique peut aussi comporter des unités cartographiques particulières, associations ou complexes de sols, différentes de celles de la classification, mais constituées par un arrangement géographique de certaines de celles-ci. Chaque type de carte n'utilisera qu'un élément, plus ou moins haut placé, plus ou moins détaillé de la classification, mais qui devra toujours pouvoir être intégré dans la classification générale pour permettre les comparaisons de carte à carte, de pays à pays.

La classification des sols doit être utilisable sur le terrain. Les caractères définissant chacune des catégories, caractères intrinsèques du sol, doivent pouvoir être reconnus et appréciés sur le terrain. Il peut se faire que cela ne soit pas encore le cas pour tous. Il n'y a là qu'une imperfection qui doit disparaître au fur et à mesure que pourra être établi comment s'expriment dans le profil du sol les éléments fondamentaux retenus comme base de différenciation des diverses catégories de la classification. Les analyses effectuées au laboratoire doivent surtout permettre, à ce point de vue, de confirmer et de préciser le diagnostic effectué sur le terrain.

Enfin, dans la mesure du possible, nous recherchons un type de classification qui soit applicable, et, plus particulièrement, à la détermination des caractères de fertilité de ces sols, ainsi qu'à la solution des problèmes agronomiques que pose leur mise en valeur.

Les classifications des êtres vivants sont fondées sur le principe de parenté et de filiation. Il ne peut en être de même pour la classification pédologique. Un sol ne provient pas d'un autre sol, et, même dans le cas de deux sols d'une même chaîne, certains éléments, seulement, de l'un proviennent de l'autre. Cependant la genèse d'un sol dépend d'un certain nombre de facteurs dont l'action combinée lui donne naissance. Aussi, toute classification qui tient compte ou qui exprime ces conditions et processus de formation et d'évolution, et donc, en premier lieu, toute classification de base génétique, se rapproche-t-elle le plus de ce principe de parenté et de filiation.

La classification pédologique doit cependant rester une classification des sols eux-mêmes, et ne pas devenir celle de leurs modes de formation. Fondée sur la pédogénèse elle doit donc s'exprimer par les caractères intrinsèques des sols. Ils doivent être observés dans leur profil, mais le sol n'étant pas seulement ni mono-, ni bi-, mais tri-dimensionnel, c'est dans l'ensemble du profil suivant ses trois dimensions, ou, si l'on préfère, dans leur profil replacé dans l'ensemble du paysage, qu'ils doivent être étudiés. Enfin l'un des facteurs d'évolution du sol est son âge, et le sol est un élément naturel souvent doté d'un très grand âge qui peut s'exprimer en dixaines et, parfois, en centaines de millénaires; il a évolué dans des ensembles de conditions qui ont pu varier au cours des temps et il a pu garder des traces de chacun; la classification pédologique doit donc en tenir compte, et l'exprimer au moins dans les cas les plus typiques.

La classification utilisée par la plupart des pédologues français, dans son intégralité ou avec quelques légères modifications de détail, a été d'abord mise sur pied par Albert Demolon et V. Oudin. Elle a été ultérieurement complétée et, plus ou moins, transformée à la suite des travaux de J. Boulaine, Ph. Duchaufour, J. Dupuis, P. Roederer et des pédologues de l'O.R.S.T.O.M. travaillant en pays tropicaux, R. Maignien, J. Riquier, M. Brugière, P. Ségalen, N. Leneuf, J. Pias, etc. ainsi que des études détaillées, assez abondantes maintenant, faites en métropole par R. Bétrémieux, Servat, J.P. Desaunettes, Delmas etc.

Elle envisage le sol dans la totalité de son profil depuis la roche inaltérée qui lui a donné naissance jusqu'à sa surface. Les unités en sont définies par les caractères mêmes des sols qui les composent; elles sont rassemblées en fonction des conditions et des processus de leur évolution. Elle est donc essentiellement de type pédogénétique, tout en gardant son caractère de classification intrinsèque de sols. Elle tient compte de l'ensemble des modes d'évolution qui ont pu affecter le sol, évolution possiblement ancienne ou poursuivie depuis très longtemps, telle celle qui a provoqué l'altération ferrallitique, par exemple, de nombreux sols tropicaux ou évolution plus récente et plus rapidement efficace due, par exemple, à l'action de la matière organique. Les paléosols y sont intégrés soit, suivant les cas, au niveau des groupes et sous-groupes, soit à celui des familles.

Elle comporte la répartition des sols en classes et sous-classes en fonction des conditions physiques ou climatiques, physico-chimiques et chimiques d'évolution des sols, qui s'expriment par un certain nombre de caractères essentiels :

1. Degré d'évolution du sol et développement du profil : sols en voie de formation ou « présols » désignés en tant que sols minéraux bruts; sols jeunes, assez peu évolués encore, ne comportant pas un profil nettement différencié; et différentes classes de sols évolués à profil A(B)C ou ABC, correspondant à divers processus de formation.

2. Mode d'altération, défini par la nature des sesquioxydes libérés et qui se maintiennent individualisés ou constituent des complexes caractéristiques et par l'intensité relative de cette libération, ainsi que par la dominance de certains types d'argile; critères qui s'expriment dans le profil à la fois par des couleurs et des propriétés physiques, structure en particulier, de certains horizons; ou par la morphologie du matériau originel qui peut être, suivant les cas, poudreux ou sableux.

3. Type de répartition de la matière organique, susceptible d'influer sur l'évolution du sol et la différenciation des horizons du profil — concentration organique dans les horizons supérieurs, ou répartition « isohumique » plus ou moins régulière dans tout le profil; humus évolué calcique; humus évolué de type mull, apte à favoriser la migration des colloïdes argileux; humus grossier à dominance du type mor, capable de dégrader le complexe minéral des sols; humus dit « anmoor »; humus tourbeux.

4. Certains phénomènes fondamentaux d'évolution, tels que l'hydromorphie (ou hydro-genèse) et l'halomorphie (ou halo-genèse). Ces deux types de processus diffèrent certainement des précédents en ce qu'ils sont, non pas vraiment « transitoires » comme il a été dit parfois, mais beaucoup plus rapides que ceux des trois catégories ci-dessus. Cependant ils peuvent être si développés qu'ils dominent entièrement le mode d'évolution du sol et l'expression de son profil. En ce cas seulement, d'ailleurs, ils sont pris comme caractéristiques de classes de sols; moins intenses, ou moins intensément exprimés, ils ne définissent que des groupes et surtout des sous-groupes, séries ou phases de sols.

A ce niveau (sous-classes) sont aussi prises en considération les conditions de pédoclimat, difficiles, il est vrai, à préciser, mais dont l'influence est si considérable dans l'évolution des sols.

Les classes et sous-classes sont subdivisées en groupes de sol, définis par des caractères morphologiques du profil correspondant à des processus d'évolution de ces sols : différenciation de certains horizons, lessivage du calcaire, des éléments colloïdaux, etc. Parfois deux groupes voisins peuvent être caractérisés par un même processus pédologique général; ils sont alors différenciés par une forte variation de son intensité correspondant à des profils

nettement distincts. Tels sont les cas des groupes Podzoliques et des Podzols, dans la classe des sols à humus grossier et hydroxydes; ou des groupes Châtains, Bruns, etc. dans la classe isohumique ou steppique; ou des groupes Ferrallitiques et faiblement Ferrallitiques dans celle des sols à sesquioxydes et humus bien évolué.

Les groupes comprennent, en général, plusieurs sous-groupes dont les caractères essentiels des profils sont les mêmes, mais qui sont différenciés soit par une intensité variable, d'une catégorie à l'autre, du processus fondamental d'évolution caractéristique du groupe, soit par la manifestation d'un processus secondaire, indiquée par certains éléments nouveaux du profil (concrétionnement, induration, taches d'hydromorphie, élargissement de la structure, etc.).

Dans certaines études assez détaillées on peut être amené à définir dans les sous-groupes des « faciès » de sols, correspondant à des stades ou à des types d'évolution intermédiaires entre ceux de deux sous-groupes. Ces faciès ne paraissent pas assez nettement caractérisés actuellement pour être retenus à l'échelle mondiale; ils ont le plus souvent, dès maintenant, une valeur régionale.

A l'intérieur des sous-groupes ou faciès nous distinguons des familles de sols, en fonction des caractères pétrographiques de leur matériau originel : nature, dureté et résistance à la décomposition, cohésion, perméabilité, richesse en bases, etc. Les séries y correspondent à des différenciations de détail du profil : profondeur du sol, de l'horizon d'accumulation ou induré, épaisseur de certains horizons principaux, forte teneur en éléments grossiers et, le cas échéant, position dans le « paysage ».

Dans certains cas, les séries sont subdivisées en types de sols en fonction des caractères précis de la texture de leurs horizons supérieurs, et en phases qui correspondent à de faibles variations des profils par suite de modifications temporaires ou d'actions de courte durée : mise en culture, faible érosion, etc.

La classification que nous utilisons actuellement est, certes, déjà bien différente de celle qui fut présentée en de précédentes réunions internationales, Léopoldville 1954, Paris 1956, Dalaba 1959 e.a. Elle est encore inachevée et devra évoluer. De nouveaux sous-groupes et de nouveaux groupes de sols peuvent être observés qui n'ont pas encore été décrits ou étudiés ou pas suffisamment pour qu'ils puissent y être placés avec certitude; certains rapprochements pourront être modifiés quand nous comprendrons mieux le pourquoi d'analogies qui, actuellement, nous frappent.

Dans son état actuel cette classification comprend les Classes, Sous-classes, Groupes et Sous-groupes que nous indiquons dans les pages qui suivent.

CLASSE I : SOLS MINERAUX BRUTS

La première classe est celle des Sols Minéraux Bruts, dont le profil est de type (A)C. Leur évolution a été très faible et ils ne présentent dans l'horizon supérieur que des traces de matière organique. L'argilification y est très réduite.

On peut sur la base du pédoclimat des sols qui les composent, y distinguer deux sous-classes.

1) Sols Minéraux Bruts dont la très faible évolution est due aux conditions climatiques qui s'expriment par un pédoclimat ou très froid ou très sec tout au long de l'année. Ce sont les *Sols Polygonaux,* non humifères, des pays froids (Sols Polygonaux Typiques, et Sols Réticulés), et les *Sols des Déserts.* Ce dernier groupe se subdivise en sous-groupes, d'après les caractères morphologiques imprimés aux sols par les processus mécaniques qui leur ont donné naissance : modelé éolien vif, en ergs, barkhanes, nebkhas et microdunes ou voiles sableux, des Sols d'apport des Déserts; lit de sable grossier, graviers et cailloux, des Sols d'ablation des Déserts; amas de grosses pierres éclatées, et de débris non ordonnés, souvent recouverts de vernis d'oxydes métalliques, des Sols non soumis à mouvement des Déserts.

2) Dans la seconde sous-classe, sont placés les sols dont le pédoclimat ni très sec, ni très froid toute l'année, peut permettre leur évolution. C'est par suite de phénomènes mécaniques qu'ils n'évoluent pas davantage.

a) *Sols Bruts d'érosion,* à peine développés sur les roches en pente, et qui comprennent les Lithosols sur matériau impénétrable aux racines, et les Régosols;

b) *Sols Bruts d'apport* que l'on peut subdiviser, d'après la structure du matériau, résultant du mode de transport et l'exprimant, en Sols d'apport fluviatile; Sols d'apport marin; Sols d'apport éolien; Sols d'apport continental.

CLASSE II : SOLS PEU EVOLUES

Les sols de la seconde classe, Sols peu Evolués, sont caractérisés par un profil AC. Leur horizon humifère est, en général, peu épais, de 10 à 30 cm environ, rarement davantage, ou peu organique s'il est plus épais. Leur matière organique peut être très variable comme type; les minéraux y sont peu évolués ou n'ont guère dépassé le stade d'évolution qu'ils avaient atteint dans le matériau originel.

La subdivision en sous-classes a été maintenue encore actuelle-

ment à ce qu'elle a été indiquée dans les approximations précédentes, depuis 1956, c'est à dire la même que pour la classe I.

1) Dans la première sous-classe dont les sols ont leur évolution limitée par les caractères de leur pédoclimat, froid, ou assez froid et très humide, ou sec, pendant la plus grande partie de l'année, sont rassemblés trois groupes très différents dont le seul lien est l'origine climatique de leur faible évolution.

a) *Sols de Toundra,* gelés pendant une partie de l'année et assez humifères, à humus grossier.

b) *Rankers,* dont l'horizon organique passe brutalement à la roche-mère; ils sont riches en matière organique : Rankers Alpins proprement dits, peu épais, dont l'humus est de type grossier; Rankers Atlantiques, à matière organique plus évoluée et dont l'épaisseur est moins réduite.
Des sols tout à fait identiques aux Rankers existent en certaines positions particulières en pays tropical. Leur matière organique assez peu évoluée, leur faible épaisseur et la brutalité de leur passage à la roche sous-jacente permettent d'en faire un troisième sous-groupe de ce groupe, celui des Rankers Tropicaux, voisin des deux précédents. Ils sont presque toujours situés sur une roche horizontale, imperméable, difficilement altérable, et dont les produits de décomposition sont très pauvres en aliments pour les micro-organismes : dalles de grès quartzeux, cuirasses ferrugineuses ou ferrallitiques. Il s'en trouve aussi parfois, en petites taches, sur des dômes granitiques dénudés. Ils sont gorgés d'eau pendant une partie de l'année.

c) *Sols Gris Subdésertiques,* dont le profil est peu épais, généralement moins de 50 cm (sauf en milieu très perméable ou sur certaines alluvions qui ont continué à se constituer pendant que le sol se formait), et la teneur en matière organique très faible (quelques pour mille seulement sur 20 cm, sous végétation naturelle), quoique répartie régulièrement sur l'ensemble du profil.
Leur structure est le plus souvent lamellaire en surface, donnant parfois naissance à une croûte faiblement durcie sur 1 à 2 cm, puis faiblement nuciforme à polyédrique. Leur teneur en calcaire est assez constante ou présente une légère accumulation dans l'horizon supérieur. Les sels solubles tendent à s'accumuler en surface pendant l'ensemble de l'année.

Nous y avons distingué les sous-groupes suivants :
— Sols Subdésertiques Modaux;
— Sols Subdésertiques faiblement Salés ou Alcalisés;
— Sols Subdésertiques Eolisés par déflation;
— Sols Subdésertiques Eolisés en microdunes.

Ces deux dernières modifications du profil de ces sols sont si fréquentes et prennent une telle importance parmi leurs caractères, peu accentués par ailleurs, qu'il paraît préférable de les faire intervenir au niveau des sous-groupes plutôt qu'à celui des séries ou des phases comme pour d'autres groupes.

2) Dans la deuxième sous-classe, les sols sont jeunes ou rajeunis.

a) *Sols peu Evolués d'érosion,* humifères, toujours peu épais; sur roches impénétrables, ce sont les Sols Lithiques; sur roches pénétrables aux racines, les Sols Régosoliques (Sols Régiques).

b) *Sols peu Evolués d'apport.* Leur évolution un peu plus poussée que dans les Sols Minéraux Bruts d'apport permet de prendre, comme base de leur classification, non les caractères dus à leur mode de dépôt, déjà plus ou moins effacés par leur évolution commençante, mais ceux dus au drainage, ou à d'autres phénomènes fréquents en pareil cas, tels que l'action du sel.

Les trois sous-groupes suivants peuvent être séparés :

— Sols peu Evolués d'apport bien Drainés;
— Sols peu Evolués d'apport Hydromorphes;
— Sols peu Evolués d'apport faiblement Salés ou Alcalisés.

Ces divers sous-groupes et, en particulier, le sous-groupe modal, bien drainé, sont souvent subdivisés en faciès; ainsi en Tunisie, ont été distingués les suivants : calcimorphes, isohumiques, brunifiés. Il est souvent utile, en pays subhumide à semi-aride chaud, de prévoir aussi un faciès vertisolique (ou vertique) ou tirsifié.

CLASSE III : VERTISOLS ET PARAVERTISOLS

La troisième classe est celle des Vertisols et Paravertisols. Ils sont caractérisés par un profil A(B)C ou A(B)gC, l'horizon de gley pouvant d'ailleurs apparaître aussi en A, d'autant plus que dans ces sols l'hydromorphie est de surface ou d'ensemble, tout en restant temporaire.

Ce sont des sols à structure très grossière, prismatique à polyédrique sur au moins la plus grande partie de leur profil, et en plaquettes à leur base. Les surfaces de glissement y sont nettes et les faces lissées fréquentes. Leur consistance est très élevée et leur cohésion très forte, dès que secs. Ils possèdent une couleur foncée relativement à leur teneur en matière organique. Souvent très argileux, ils n'atteignent pas toujours la limite de 35 p. 100 fixée par la 7ème Approximation du SCS-USDA. Il est exact aussi qu'ils présentent fréquemment une dominance argileuse de type montmorillonitique; elle n'est pourtant pas constante et certains Para-

vertisols sont essentiellement riches en illite ou en kaolinite et gels de silice.

La classification de ces sols présente de nombreuses difficultés. Il apparaît en effet que, par suite de leur moindre extension géographique, ainsi que du moindre degré de généralité et du degré plus élevé de caractérisation de leurs critères de définition, et de leur processus de formation, ils correspondent plutôt à une sous-classe qu'à une classe. Ils pourraient être rattachés à la classe Hydromorphe, mais certains d'entre eux n'en présentent qu'assez peu les caractères essentiels (Côte d'Ivoire, Togo); ou à la classe Calco-Magnésimorphe, mais certains sont acides (Tchad) et ne contiennent que peu de calcium ou de magnésium (Tunisie), dans leur complexe.

Aussi avons nous été amenés à en faire une classe à part, proche des classes Calco-Magnésimorphe et Isohumique, la classe Hydromorphe étant obligatoirement en fin de tableau, séparée des précédentes. On peut d'ailleurs concevoir de mettre ces sols en classe IV après les Sols Calco-Magnésimorphes, et juste avant les Sols Isohumiques.

Les deux sous-classes sont différenciées sur la base du pédoclimat de leurs sols.

1) Vertisols très hydromorphes, à pédoclimat très humide pendant des périodes prolongées; ils se trouvent, le plus souvent, en zone plane ou déprimée (Vertisols Topomorphes ou Topo-Lithomorphes). Dans un premier groupe sont les *Vertisols Topomorphes Grumosoliques* qui présentent une structure fine, polyédrique à nuciforme dans un horizon superficiel d'au moins 20 cm; dans un second groupe, la structure large, la forte compacité et la cohésion très élevée commencent dès la surface du sol, ce sont les *Vertisols Topomorphes non Grumosoliques.*

2) La seconde sous-classe comporte les sols à pédoclimat seulement temporairement humide. Ils sont situés sur des pentes — jamais très fortes d'ailleurs — qui en facilitent l'assainissement. Leur hydromorphie d'engorgement est essentiellement d'origine pétrographique. Leur roche-mère comporte une proportion élevée d'argile gonflante ou de minéraux ferro-magnésiens qui, par altération dans les conditions de climat tropical ou subtropical suffisamment chaud pendant la période de pluie, et de pluviométrie moyenne à assez élevée (400 à 1200 mm env.), donnent naissance à ce type d'argile.

Ces *Vertisols Lithomorphes* sont subdivisés en groupes, *Grumosoliques* ou non, sur les mêmes bases que dans la sous-classe précédente.

CLASSE IV : SOLS CALCO-MAGNESIMORPHES

La quatrième classe, que l'on pourrait, semble-t-il, placer plus justement avant la précédente, à cause de son profil de type AC et, plus rarement A(B)C, est celle des Sols Calco-Magnésimorphes.

L'évolution de ces sols est dominée par la présence et l'action de sels (carbonate ou sulfate) de calcium et magnésium dont la teneur est élevée et pratiquement constante dans l'ensemble du profil.

1) Dans une première sous-classe, les sols sont riches en matière organique bien humifiée. Cette « richesse » s'entend, naturellement, relativement aux sols non Calco-Magnésimorphes des mêmes régions. Bien pourvus en carbonate actif de calcium et magnésium, ils possèdent une structure en agrégats nettement définis et de taille fine, ou, au maximum, moyenne, souvent grenue à nuciforme, parfois polyédrique.

a) Dans un premier groupe, celui des *Rendzines Vraies,* sont classés tous les sols de cette catégorie, à profil AC. Leur structure, nettement définie, est à éléments arrondis, grenus ou nuciformes, plus rarement grumeleux. Elle leur confère un type de pédoclimat que l'on retrouve dans les Rendzines sableuses. Aussi, classons nous ces dernières dans ce groupe malgré leur structure monoparticulaire. Les sous-groupes actuellement reconnus sont ceux des Sols Humo-carbonatés, formés essentiellement d'agrégats de matière organique et d'éléments calcaires, et les Rendzines Typiques, subdivisées en faciès gris ou noir, rouge et blanc.

Il a été proposé d'y adjoindre un troisième sous-groupe, celui des « Rendzines initiales ». Assez peu humifères cependant, elles peuvent être plutôt classées avec les sols peu évolués d'érosion (Classe II).

b) Le groupe suivant est celui des *Rendzines à horizons,* à profil A(B)C, dont l'horizon (B) se distingue par sa structure généralement polyédrique, parfois à tendance prismatique, sa consistance ou sa couleur. La teneur en calcaire de (B) peut être un peu supérieure à celle de A.

On y distingue :

— Sous-groupe des Sols Humo-carbonatés Acidifiés en surface, sous l'influence d'une végétation donnant des résidus lents à s'humifier (pins en Champagne, rhododendrons et bruyères dans certaines parties des Alpes) malgré la haute teneur en calcaire actif du matériau sous-jacent.

— Sous-groupe des Rendzines Dégradées, présentant, au-dessous d'un horizon de rendzine souvent assez typique, un horizon enrichi

en composés ferrugineux, ocre rouille, parfois réduit à une ligne épaisse.

— Sous-groupe des Sols Bruns Calcaires comportant un horizon (B) à structure polyédrique moyenne à fine, parfois à tendance prismatique, moins poreux dans son ensemble que les horizons de rendzines. Ce type de structure peut apparaître pratiquement dès la surface.

— Sous-groupe des Sols Bruns Calcaires Hydromorphes. Analogues aux précédents, les sols de ce sous-groupe s'en distinguent cependant, par l'élargissement de la structure de (B) dont la tendance prismatique s'exagère.

A la limite, ces derniers dont la couleur tend à devenir plus foncée, peuvent passer à des Vertisols et Paravertisols (Classe III).

c) Un troisième groupe est celui des *Rendzines Dolomitiques* ou *Magnésiennes.*

Elles sont souvent très foncées, et leur structure est plus fréquemment monoparticulaire que grenue.

Actuellement, nous n'y distinguons que deux sous-groupes : Rendzines Dolomitiques Vraies et Rendzines Dolomitiques Dégradées. On les différencie comme les Rendzines Vraies et les Rendzines Dégradées des groupes précédents.

Les Rendzines Dolomitiques Dégradées ne paraissent pas assez fréquentes, même dans des pays à roches magnésiennes très abondantes comme la Nouvelle Calédonie, pour pouvoir constituer un groupe.

2) La deuxième sous-classe est celle des Sols à accumulation gypseuse.

Elle ne comprend qu'un groupe, celui des *Sols à accumulation gypseuse localisée.* Contrairement à ce que l'on observe dans d'autres sols gypseux, que l'on classe alors comme hydromorphes, cette accumulation n'est pas due à une action de nappe phréatique. Sur un matériau gypseux — argile à gros cristaux de gypse par exemple — se constituent des horizons différenciés par la taille de cristallisation de leurs éléments et par leur teneur en gypse, qui augmente en surface.

Suivant la forme que revêt cette accumulation, ils sont subdivisés en deux sous-groupes : Sols à croûte gypseuse (accumulation durcie, souvent découpée en hexagones, plus rarement en rectangles) et Sols à encroûtement gypseux, dont l'horizon d'accumulation reste friable.

CLASSE V : SOLS ISOHUMIQUES

La cinquième classe est celle des Sols Isohumiques ou Step-

piques caractérisés par une teneur relativement élevée en matière organique, sous végétation naturelle, bien humifiée, et progressivement décroissante en profondeur.

Cette richesse en matière organique doit être notable sur au moins 50 cm ou, si le profil du sol ne dépasse pas 50 cm, sur au moins 30 cm, et toujours sur plus de la moitié du profil.

Ce sont des sols de profil AC ou A(B)C.

On observe des Sols Isohumiques ayant une plus forte teneur en argile en B. Il ne s'agit pas là du résultat d'une migration des éléments, mais de celui d'une argilification préférentielle en profondeur.

1) Une première sous-classe réunit ceux de ces sols dont le complexe est partiellement désaturé, et la structure polyédrique fine presque dès la surface. Elle ne comporte que le groupe des *Brunizems* ou *Sols de la Prairie.*

On y distingue les sous-groupes suivants :

— Brunizem Modal, bien drainé sans horizon B textural;
— Brunizem à horizon B textural mais non hydromorphe;
— Brunizem à pseudogley;
— Brunizem Vertique à horizon B textural présentant une structure élargie à tendance prismatique.

Certains pédologues tendent cependant à reconnaître aussi des sous-groupes de Brunizems Lessivés ou Brunizems Podzolisés. N'en ayant jamais observés, nous ne les incluons pas actuellement dans cette classification.

2) Parmi les Sols Isohumiques possédant un complexe saturé, principalement en calcium, nous distinguons trois sous-classes. Elles sont séparées sur la base des caractères de leur pédoclimat, et, en particulier, de la concordance ou non des périodes d'humidité et de température élevée du sol; elles sont définies par les critères morphologiques qui en résultent : richesse en matière organique, migration du calcaire, teneur relative en fer libre.

La deuxième sous-classe groupe les sols à complexe saturé dont le pédoclimat, très froid pendant une longue période de l'année, limite la minéralisation de la matière organique. Aussi ont-ils une richesse organique relativement forte.

On y distingue quatre groupes.

a) Les *Chernozems* ont une teneur très élevée en matière organique (supérieure à 8 p. 100 sur au moins 20 cm) sous végétation naturelle et sont dépourvus de calcaire dans leur horizon superficiel. Celui-ci s'accumule en profondeur, souvent à 80 cm ou 1 m. Leur structure est grumeleuse, grenue ou nuciforme dans l'ensemble du profil.

Nous y reconnaissons les sous-groupes suivants, fréquemment admis par les auteurs, et par les Russes en particulier :

— Chernozems très humifères (plus de 13 p. 100 de matière organique);
— Chernozems Modaux;
— Chernozems peu profonds;
— Chernozems Dégradés (?)

b) Les *Sols Châtains* n'ont que 3 à 8 p. 100 de matière organique dans leur horizon supérieur qui peut être encore, mais faiblement, calcaire. L'accumulation de ce calcaire se fait, pour une même texture et une même perméabilité des matériaux, à moindre profondeur que dans le cas des Chernozems; elle peut y devenir très importante et donner naissance à un véritable encroûtement.
Ils sont parfois, en certaines zones à température moyenne assez élevée, comme dans le Sud des Etats Unis, assez bien pourvus en oxydes de fer individualisés, ce qui leur donne une couleur plus rouge.

Aussi y distingue-t-on :

— Sols Châtains Modaux;
— Sols Châtains-Rouge;
— Sols Châtains Vertisoliques (ou Vertiques);
— Sols Châtains à gley ou pseudogley;
— Sols Châtains Encroûtés.

c) Les *Sols Bruns Isohumiques* ont une teneur plus faible en matière organique dans l'horizon superficiel (moins de 3 p. 100) et leur profil calcaire comporte un lessivage superficiel accentué et une accumulation à moyenne profondeur (souvent vers 40 à 50 cm). On y distingue les sous-groupes suivants :

— Sols Bruns Isohumiques Modaux;
— Sols Brun-Rouge;
— Sols Bruns Isohumiques Vertisoliques (ou Vertiques);
— Sols Bruns Isohumiques à gley ou pseudogley;
— Sols Bruns Encroûtés.

Nous avons précédemment compris dans cette sous-classe un quatrième groupe de *Siérozems*. Il semble qu'il soit préférable de réserver ce terme pour des sols de pseudo-steppe formés en climat subtropical semi-aride.
Les sols des steppes arides soumises à de longues périodes froides chaque année sont trop peu évolués, semble-t-il, pour être placés dans cette classe; ce sont des *Sols Gris Subdésertiques*, dont nous avons indiqué précédemment la position en classe II; nous en avons, alors, donné les principaux caractères.

3) La troisième sous-classe correspond à celle des sols des pseudo-steppes des régions subtropicales ou méditerranéennes. Ce sont des Sols Isohumiques qui présentent un pédoclimat frais mais non froid en période de pluie et qui ont, de ce fait, une teneur en matière organique faible relativement à la pluviométrie des régions où ils se trouvent et à l'intensité de développement de leur végétation steppique. La décarbonatation y est moins intense que dans les sols de la sous-classe précédente.

L'altération des minéraux, dans la plupart de ces sols, est plus poussée dans les horizons profonds que dans les plus superficiels. La teneur en éléments fins y est aussi plus élevée en profondeur qu'en surface, sans qu'il soit possible d'y déceler une migration d'argile. Ils sont souvent, au moins faiblement, rubéfiés.
Ils correspondent, pour une part aux *Sols Marron* de certains auteurs russes.

Les groupes suivants y sont distingués.

a) *Sols Châtains Subtropicaux* qui, sous végétation naturelle ont une teneur en matière organique supérieure à 1,8 p. 100 dans l'horizon superficiel. La décarbonatation y est très poussée, souvent presque totale, en surface. Leur structure, grumeleuse à nuciforme dans l'horizon supérieur, devient prismatique fine à moyenne en profondeur.

Ils comprennent les sous-groupes suivants :

— Sols Châtains Subtropicaux Modaux;
— Sols Châtain-Rouge Subtropicaux;
— Sols Châtains Subtropicaux Encroûtés (à croûte calcaire);
— Sols Châtains Subtropicaux Vertisoliques (ou Vertiques) à horizons profonds plus largement structurés, présentant souvent une structure en plaquettes à leur base;
— Sols Châtains Subtropicaux à gley ou pseudogley.

b) *Sols Bruns Isohumiques Subtropicaux* qui ont une teneur plus faible en matière organique (de l'ordre de 1 à 1,8 p. 100 en surface, sous végétation naturelle). Leur décarbonatation, nette, est cependant moins poussée que dans les Sols Châtains; l'accumulation se fait, à moyenne ou à faible profondeur (sommet de cet horizon à 30-60 cm env.), sous forme d'amas friables, nodules ou granules. Elle peut même provoquer l'apparition d'un véritable encroûtement. Leur structure est grumeleuse à nuciforme en surface, parfois lamellaire (sous culture); elle est généralement polyédrique, moyenne à fine, en profondeur.
La subdivision en sous-groupes des *Sols Bruns Isohumiques Subtropicaux* est la même que dans les cas du groupe précédent.

On y distingue, cependant, en outre, un sous-groupe de Sols Bruns Isohumiques Subtropicaux faiblement Salés ou Alcalisés, qui n'a pas lieu d'être retenu, semble-t-il, dans le groupe Châtain.

c) Les *Sierozems* sont des sols isohumiques des régions subtropicales ou méditerranéennes, dont la teneur en matière organique est peu élevée. La migration du calcaire y est faible; il s'y produit parfois un certain encroûtement gypseux.

L'argilification préférentielle en profondeur ne s'y observe généralement pas. Leur structure est analogue à celle des sols du groupe précédent, mais souvent moins développée.

Les sous-groupes y sont les suivants :

— Sierozems Modaux;
— Sierozems Encroûtés (à encroûtement gypseux);
— Sierozems Hydromorphes;
— Sierozems faiblement Salés ou Alcalisés.

4) La quatrième sous-classe est celle des *Sols Isohumiques des pseudo-steppes tropicales.* Leur pédoclimat est chaud lorsqu'il est humide, aussi leur teneur en matière organique est-elle « relativement » faible (mais, cependant, plus élevée que dans les sols non isohumiques des mêmes régions).

L'individualisation des sesquioxydes s'y fait largement, mais la rubéfaction n'y est pas toujours visible. L'argilification en profondeur y est peu développée.

Les sous-groupes y sont les suivants :

— Sols Bruns Subarides Modaux;
— Sols Brun-Rouge Subarides;
— Sols Bruns Subarides Vertisoliques (ou Vertiques);
— Sols Bruns Subarides à pseudogley;
— Sols Bruns Subarides faiblement Salés ou Alcalisés.

CLASSE VI : SOLS A MULL

La VIème classe est celle des « Sols à Mull », sols formés sous l'influence d'une matière organique fortement évoluée, à humus de type « mull », et ne comportant que peu de sesquioxydes métalliques (de fer en particulier) libérés qui restent, par ailleurs, liés au complexe argilo-humique. Leur profil est de type A(B)C ou ABC.

Comme la classe précédente, elle est subdivisée sur la base des conditions de pédoclimat des sols qui la constituent.

1) La première sous-classe est celle des Sols à Mull des pays tempérés. Leur pédoclimat est frais pendant toute l'année, ou au moins

pendant la saison des pluies. La libération des sesquioxydes de fer y est particulièrement limitée.

a) Le *Groupe Lessivé* comprend les « sols à mull » de profil ABC dans lesquels l'horizon B correspond à une nette accumulation d'argile qui a migré depuis l'horizon supérieur. L'indice de lessivage y est inférieur à 1/1,4. L'accumulation qui doit être décelable de façon certaine, aussi bien analytiquement au laboratoire que morphologiquement sur le terrain, ne peut pratiquement être prise en considération que lorsqu'elle s'exprime par une différence de teneur en argile d'au moins 4 à 5 p. 100 (en valeur absolue) entre les deux horizons, le plus lessivé et le plus enrichi.

L'horizon B présente souvent des revêtements, qui ne doivent pas être confondus avec les faces lisses des agrégats de certains sols hydromorphes ou les faces lustrées de ceux de certains sols ferrallitiques. Leur existence, en ce cas, est une preuve de la migration de l'argile. Ils peuvent, cependant, ne pas être observables, semble-t-il, sur le terrain dans certains sols pourtant typiquement lessivés. L'horizon éluvial peut être divisé en A_1 et A_2, mais ce dernier, même très clair, n'est jamais cendreux.

Cinq sous-groupes constituent actuellement le groupe Lessivé.

— Les Sols Lessivés faiblement Podzoliques, intermédiaires avec les sols de la classe suivante, contiennent déjà une certaine proportion de « moder » dans leur humus. L'horizon B y est très accusé (indice de lessivage en général inférieur à 1/3) et présente déjà, souvent, une couleur plus rouge ou plus rouille, indiquant une accentuation de la libération des sesquioxydes de fer.

L'horizon A_2 y est très nettement séparé de A_1; il est très clair souvent blanchi.

Par certains de leurs caractères, les Sols Rouges et Jaunes Blanchis (« Red and Yellow podzolic soils » des USA) des régions chaudes s'en rapprochent. Ils n'ont pas, actuellement, de place précise dans notre classification; ce point est à l'étude (G. Tercinier — IFO — NOUMEA — Nouvelle Calédonie).

— Les Sols Lessivés Modaux correspondent au type même de ce groupe. Leur indice de lessivage est compris entre 1/3 et 1/2. A_2 y est net et clair mais non blanchi; B est très distinct.

— Les Sols Bruns Lessivés présentent encore une différence accusée entre A et B, mais celle qui existe entre les deux horizons A_1 et A_2 est beaucoup moins nette.

— Les Sols Lessivés obliquement ont subi, eux aussi, une certaine migration d'argile; elle s'est produite, non verticalement, mais au long de la pente, à l'intérieur du sol. L'accumulation s'y fait non

à la verticale de l'horizon lessivé, mais là où le drainage à faible profondeur est ralenti comme en bas de pente. Ils sont rares.

— Les Sols Lessivés Hydromorphes peuvent, suivant les cas, être caractérisés par un élargissement de la structure de leur horizon B, ou par l'apparition, dans cet horizon d'accumulation et surtout à sa partie supérieure, de taches et concrétions d'oxydes de fer et de manganèse.

b) Lorsque les sols de cette sous-classe ne présentent plus, ni dans leur profil, ni à l'analyse, les caractéristiques d'une migration notable des éléments colloïdaux, ils sont classés dans le *Groupe Brun*. Le profil correspondant est de type AC ou, le plus souvent, A(B)C, sa base se différenciant un peu de sa partie supérieure par sa couleur plus brune ou rouille, et sa structure généralement plus polyédrique.

Dans un premier sous-groupe, celui des Sols Bruns faiblement Lessivés, l'on observe encore une certaine migration de l'argile; mais le rapport d'entraînement est compris entre 1/1,4 et 1/1,1; ou la différence de teneur en argile est inférieure à 4 ou 5 p. 100, tout en restant morphologiquement sensible.

Dans le sous-groupe des Sols Bruns Tempérés Modaux, le profil est homogène. Ils présentent souvent une grande activité de la faune. Leur réaction est voisine de la neutralité sur son ensemble (pH supérieur à 6 tout au long des saisons) et, spécialement, dans leurs horizons supérieurs, plus humifères.

Dans le sous-groupe des Sols Bruns Acides, l'ensemble des caractères du sol est identique à ceux des sols des deux sous-groupes précédents. Ils sont cependant réunis en un sous-groupe spécial, par suite de leur réaction fortement acide (pH inférieur à 6) sur l'ensemble du profil et surtout dans le matériau originel.

Un quatrième sous-groupe est celui des Sols Bruns Hydromorphes, à gley ou à pseudogley, présentant des taches et traînées d'oxydes de fer ou de manganèse, et parfois même des concrétions durcies.

2) Dans une seconde sous-classe, sont rangés les Sols à Mull dont le pédoclimat est à la fois, au moins temporairement, chaud et humide comme dans les pays tropicaux.

L'argilogenèse y est forte et une certaine individualisation des sesquioxydes s'y produit, limitée, peut-on penser, par la richesse du complexe en bases. Ces sols ont, en effet, toujours une réaction voisine de la neutralité.

Elle ne comprend actuellement qu'un groupe, celui des *Sols Bruns Eutrophes Tropicaux*.

Sols à humus doux, souvent assez abondant en A_1, bien lié à la ma-

tière minérale, à complexe bien saturé en bases alcalino-terreuses, ils présentent une structure nettement développée, grumeleuse à nuciforme en A, et polyédrique à cubique moyenne en (B). Ils possèdent une réserve minérale altérable assez abondante et leur fraction argileuse est, en grande partie, constituée de minéraux 2/1. Ils peuvent, sur matériaux volcaniques, contenir une certaine proportion d'allophane.

Les sous-groupes actuellement définis sont ceux qui constituent des intermédiaires avec les classes ou sous-classes des Sols peu Evolués et des Sols Ferruginaux Tropicaux ainsi que celui des Sols Bruns Tropicaux Hydromorphes.

CLASSE VII : PODZOLS

La Classe VII est celle des Podzols. Elle comprend les sols enrichis, dans au moins un de leurs horizons, en sesquioxydes métalliques, principalement de fer, provenant de la dégradation des minéraux du matériau originel et du complexe minéral sous l'influence d'un humus grossier et des produits de son évolution.

Alors que les sols de la Classe précédente sont souvent dénommés « Sols à mull », ceux-ci le sont en tant que « Sols à mor ».

Le phénomène fondamental de podzolisation, dont l'intensité, plus ou moins forte, provoque la différenciation de profils caractéristiques reconnaissables, en particulier, à la couleur de leur horizon B ou (B), est, le plus souvent, accompagné par un lessivage des éléments de cette évolution, et même de l'humus, l'argile n'y migrant que dans une faible proportion et dans la mesure où se forment des composés humiques — beaucoup plus fréquents dans le Mull —, capables de former avec elle un complexe stable en ce milieu acide.

Il apparaît alors, presque toujours, un horizon très lessivé A_2, de couleur très blanche ou cendreuse et de structure cendreuse, quoique, parfois, plus ou moins lamellaire.

Se formant en milieu très humide, mais sur matériau au moins assez perméable, ces sols possèdent souvent des profils dont la base présente des marques de gley. Leur existence ou leur absence permet de distinguer deux sous-classes.

1) Sous-classe des « Sols à mor » sans gley — action nulle ou très faible de nappe phréatique — quoique parfois plus ou moins engorgés en profondeur (pseudogley).

Elle comprend trois groupes.

a) *Podzols* à horizon A_2 à structure très nettement cendreuse et à horizon B fortement différencié indiquant, ensemble, une dégrada-

tion très poussée du complexe. Le plus souvent, il y existe, en B, un horizon d'accumulation humique.

Quatre sous-groupes y sont reconnus :

— Podzols Humiques, à faible accumulation ferrugineuse, masquée par celle, beaucoup plus intense, de l'humus;
— Podzols Humo-ferrugineux;
— Podzols Ferrugineux;
— Podzols à alios, dont au moins une partie de l'horizon d'accumulation est très durcie.

b) *Sols Podzoliques* à horizon A_2 moins nettement cendreux, à accumulation humique rare et accumulation ferrugineuse moins poussée, mais présentant souvent une certaine migration d'argile. Les sous-groupes y sont plus nombreux :

— Sols Podzoliques Humifères, comportant encore un B humique, faible;
— Sols Podzoliques Ferrugineux;
— Sols Podzoliques à pseudogley, dont l'horizon B ferrugineux est très taché ou marmorisé, présentant parfois — quoique rarement — des concrétions ferro-manganiques et l'horizon A_2 lamellaire ou massif;
— Sols Podzoliques à accumulation diffuse, dont la transition entre B et C s'étale sur plus de 20 cm, et souvent sur près de 1 m, en particulier sur roche granitique;
— Sols Podzoliques à lessivage oblique, autrefois dénommés Sols Humo-Cendreux, dont l'horizon B se constitue en bas de la pente sur laquelle les horizons A_0 et A_1, parfois accompagnés d'un A_2 peu épais, évoluent.

Peut-être y aurait il lieu d'ajouter ici un sous-groupe particulier pour certains sols Derno-Podzoliques des auteurs russes, encore que beaucoup d'entre eux paraissent se rattacher au sous-groupe « faiblement podzolique » du Groupe Lessivé de la Classe précédente.

Un dernier sous-groupe des Sols Podzoliques pourrait être consacré à ceux qui commencent à évoluer dans les horizons supérieurs d'un Sol Lessivé, comme cela se produit dans certaines forêts de l'Ouest de la France sur les produits d'altération de roches chimiquement pauvres et acides, à la suite, par exemple, d'une dégradation de la couverture végétale (coupe « à blanc » suivie d'un reboisement en conifères, ou de l'établissement d'un tapis de lande à base de bruyères, surmonté de quelques arbres, chênes, châtaigniers etc.). De tels sols paraissent devoir, suivant les cas, soit constituer des séries particulières de Sols Lessivés, soit être intégrés

parmi les Sols Podzoliques comme familles formées aux dépens d'anciens Sols Lessivés (matériau originel).

c) *Sols Ocre Podzoliques.* Ils présentent un horizon (B) ocre rouille et plus brun à sa partie supérieure, fortement enrichi en oxydes de fer, mais faisant suite directement aux horizons humifères. L'horizon lessivé A_2 n'existe pas. Il y a podzolisation sans lessivage; le maximum de fer libre peut se trouver près de la surface.
Aucun sous-groupe n'y a encore été différencié.

2) Sous-classe des « Sols à mor » à horizon de gley, formés en milieu très humide sous l'influence d'une nappe phréatique. La base de l'horizon B est, le plus souvent, très nettement limitée par suite des variations de niveau de cette nappe.

En fonction des caractères de l'horizon A_2 ainsi que de l'intensité de l'accumulation d'humus, on y distingue deux groupes.

a) Les *Podzols de nappe* comprenant les sous-groupes suivants : Modal, à alios et Pseudo-podzol de nappe. Dans ce dernier, assez souvent décrit en pays tropical humide ou équatorial, l'horizon d'accumulation est, pour une assez large part, le résultat du transport par la nappe, et du dépôt en une zone privilégiée, d'éléments lessivés dans tout un « paysage ».

b) Les *Sols Podzoliques à gley,* dont l'horizon A_2 est très blanchi et présente encore une structure à tendance cendreuse. L'horizon B ferrugineux est très marbré. Il peut contenir des concrétions et même être durci en alios. Ces caractères permettent de distinguer les trois sous-groupes correspondants.

CLASSE VIII : SOLS RICHES EN SESQUIOXYDES ET HYDRATES METALLIQUES

Dans la Classe VIII, les Sols sont très riches en sesquioxydes et hydrates métalliques (fer, manganèse, titane, souvent aluminium) qui ont été individualisés en présence d'un humus bien évolué, mais dans des conditions de pédoclimat suffisamment chaud pendant la période où il est, aussi, humide.

Ce phénomène s'exprime dans leur profil par la couleur rouge ou beige assez foncé de l'horizon d'accumulation ou de concentration de ces corps.

Les trois sous-classes y sont distinguées en fonction des produits résultant de cette décomposition des minéraux, de leur nature — sesquioxydes libres de fer, ou de fer et d'aluminium —, et de leur évolution. Ils peuvent se maintenir individualisés, mais se lier fortement aux surfaces des colloïdes du sol (Sols Ferrallitiques) ou en rester plus ou moins indépendants (Sols Ferrugineux Tropicaux), ou au contraire, libérés, se complexer avec d'autres

corps comme la silice (Sols Méditerranéens). Les études en cours, par exemple au CST-Bondy (ORSTOM) en liaison avec celles poursuivies dans d'autres laboratoires, tel celui du Centre d'Etude des Sols Tropicaux à Louvain, doivent permettre de préciser ces notions.

1) Dans la sous-classe des Sols Rouges et Bruns Méditerranéens, formés sur roche calcaire ou, au moins, riche en calcium (Sols Calco-Fersiallitiques), les oxydes de fer libérés constituent avec la silice, des complexes susceptibles de migrer, même en milieu calcique. La structure y est normalement grumeleuse à nuciforme, parfois polyédrique en profondeur. Elle est bien différenciée et nettement accusée. Même formé sur roche calcaire, le sol ne l'est plus, ou très faiblement seulement, mais garde un complexe largement saturé.

Le groupe des *Sols Rouges Méditerranéens* à texture relativement constante dans tout le profil, comprend, à côté du sous-groupe Modal, les sous-groupes suivants :

— Steppisé, généralement par la culture, et présentant une diminution très progressive de sa teneur en matière organique, au moins sur les deux tiers de son profil;
— Encroûté, avec un horizon plus ou moins durci d'accumulation généralisée de calcaire en profondeur;
— Hydromorphe, à taches et concrétions ferro-manganiques, ou à évolution de type vertisolique, exprimée par une couleur plus foncée relativement à sa teneur en matière organique, et une structure plus large, souvent même en plaquettes.

Dans le groupe *Rouge Méditerranéen Lessivé,* les sols présentent une nette accumulation d'argile en profondeur, provenant, par lessivage, des horizons supérieurs (au moins 4 à 5 p. 100 de variation dans la teneur en argile, et rapport de lessivage d'au plus 1/1,4). Les sous-groupes y sont les mêmes que dans le groupe précédent, mais si les sols hydromorphes à pseudogley y sont plus fréquents, ceux à tendance vertisolique y sont rares.

On distingue en outre un sous-groupe à lessivage oblique.

Le groupe des *Sols Bruns Méditerranéens* se rapproche par sa couleur, par sa teneur en sesquioxydes libres, et, moins nettement, par sa structure qui est moins accusée, des Sols Bruns Eutrophes Tropicaux. Peu étudié jusqu'à présent par les pédologues français, il n'est pas encore subdivisé en sous-groupes.

2) La deuxième sous-classe est celle des Sols Ferrugineux Tropicaux, parfois dénommés aussi Fersiallitiques.

Il s'agit de sols riches en sesquioxydes de fer et, parfois, en oxydes de manganèse, mais dépourvus d'alumine libre. Les colloïdes

minéraux y sont constitués de kaolinite mêlée d'illite et d'oxydes métalliques. La proportion de limon peut y être assez forte, et le coefficient de saturation du complexe, assez élevé, est supérieur à 40 p. 100.

Les composés ferrugineux s'y maintiennent individualisés et paraissent très libres par rapport aux surfaces des éléments minéraux. Leur matière organique, très bien évoluée, est probablement assez riche en acides humiques gris fortement polymérisés.

a) Les *Sols Ferrugineux Tropicaux non Lessivés* constituent un groupe subdivisé en deux premiers sous-groupes, en fonction d'un début de migration des oxydes de fer, ou de leur stabilité. Un troisième y réunit les sols dont l'évolution dans le sens de la « fersiallitisation » est encore assez peu accentuée, mais suffisante cependant pour qu'ils ne puissent être placés en classe II. C'est le sous-groupe des Sols Ferrugineux Tropicaux Jeunes.

b) Dans le groupe des *Sols Ferrugineux Tropicaux Lessivés,* apparaissent les sous-groupes suivants :

— Sans concrétions;

— A concrétions ferro-manganiques, généralement constituées dans la partie médiane ou profonde des horizons d'accumulation;

— Induré en carapace ou cuirasse ferrugineuse, en particulier sur les plateaux mal drainés, ou sur des pentes faibles ou moyennes dont les sols ont été décapés par érosion, après mise en culture;

— Hydromorphe à pseudogley, dont les horizons d'accumulation, et même de moyenne profondeur, sont enrichis de taches et bigarrures, souvent accompagnées de concrétions.

3) Une dernière sous-classe est celle des Sols Ferrallitiques.

Les sols, le plus souvent très profonds, y sont caractérisés par une évolution plus rapide et plus totale de la matière organique, et une décomposition plus accentuée des composés minéraux, avec un entraînement plus poussé des éléments en provenant : sels solubles, bases échangeables, silice.

Ils sont pauvres en limon et leur complexe est très désaturé (coefficient de saturation inférieur à 40 p. 100) en même temps que doué d'une capacité d'échange faible, dans sa partie minérale (au plus 20 meq pour 100 g d'argile), par suite de sa constitution fondamentale : kaolinite et sesquioxydes et hydrates de fer et d'aluminium. Contenant de l'alumine libre, amorphe ou cristallisée, ils présentent une valeur inférieure ou, au plus, égale à 2 pour le rapport SiO_2/Al_2O_3 de leurs produits d'évolution. Les sesquioxydes métalliques libérés, et maintenus individualisés, y paraissent, pour une large part, fortement liés aux surfaces du complexe minéral. Leur

structure souvent grumeleuse en surface, est formée, dans les horizons sous-jacents ou de moyenne profondeur, d'éléments bien définis, polyédriques et parfois émoussés dans le cas le plus général, grenus ou de type poudreux dans d'autres cas. Leur stabilité structurale est généralement assez élevée et peut même parfois devenir très élevée. La décomposition de leur roche-mère, même dans le cas d'une roche granitique, donne un matériau originel poudreux et non sableux, comme dans les sols des autres classes et sous-classes.

a) Un premier groupe, celui des *Sols faiblement Ferrallitiques,* réunit ceux de ces sols qui ne possèdent ces caractères qu'à un faible degré. Ils comportent à côté d'un sous-groupe Modal, un autre Ferrisolique, contenant une proportion encore importante (plus de 10 p. 100) de minéraux altérables, et un Hydromorphe. Ils peuvent aussi être indurés en carapace et cuirasse à une certaine profondeur. Cette formation particulière peut prendre naissance sous forêt. Les sols qui la présentent forment un sous-groupe particulier.

Un dernier sous-groupe y est celui des Sols Bruns Ferrallitiques Jeunes qui présentent toujours une teneur assez élevée en matière organique (4 à 6 p. 100), et souvent une saturation encore assez forte en bases. Ils constituent nettement un terme de passage avec les Sols Bruns Eutrophes Tropicaux, mais leur évolution minérale est déjà plus poussée que dans ce dernier groupe de sols.

b) Le groupe des *Sols Ferrallitiques Typiques* ou *fortement Ferrallitiques* est actuellement subdivisé en sous-groupes en fonction de la couleur de leurs divers horizons, caractère qui doit correspondre à des propriétés fondamentales, quoique encore mal définies : Sols Rouges, Sols Jaunes (ou Beiges), Sols Jaunes à horizons rouges plus profonds. Il s'y trouve aussi des Sols Indurés comme dans le groupe précédent.

c) Les *Sols Ferrallitiques Lessivés,* qui forment un troisième groupe, peuvent l'être essentiellement en bases, tout en présentant une teneur relativement constante en éléments colloïdaux minéraux. Ils peuvent aussi l'être, à la fois, en bases et en argile, et même, dans certains cas moins exceptionnels qu'on ne le pensait autrefois, être podzolisés en surface; leur humus devient alors analogue à l'humus grossier des podzols. Ils peuvent enfin être indurés à une certaine profondeur; ce processus s'accompagne alors, très souvent, d'hydromorphie à ce même niveau. Chacune de ces 4 catégories constitue un sous-groupe.

4) Le dernier groupe est celui des *Sols Ferrallitiques Humifères,* à teneur élevée (plus de 7 à 8 p. 100 sur au moins 20 cm) en matière organique bien évoluée.

Ils présentent une structure grenue à nuciforme sur toute la profondeur de l'horizon organique. Ils sont toujours formés sur roche riche en calcium.

La division en sous-groupes y différencie :

— les Sols Ferrallitiques Bruns ou Noirs très désaturés, très acides, très lessivés en bases, à rapport SiO_2/Al_2O_3 généralement très bas (parfois inférieur à 0,1) et présentant souvent un horizon B textural;

— les Sols Ferrallitiques Noirs Jeunes qui sont très riches en humus. Ils se rapprochent des Sols Andos par une certaine teneur en allophane et des Sols Bruns Ferrallitiques Jeunes qui sont, cependant, moins organiques et moins riches en bases;

— les Sols Ferrallitiques Bruns ou Chocolat, moyennement désaturés et à rapport SiO_2/Al_2O_3 nettement inférieur à 2;

— les Sols Ferrallitiques Brun-Rouge plus évolués.

Enfin, on réserve souvent un sous-groupe particulier aux Sols Ferrallitiques Humifères d'altitude, à horizon sombre, particulièrement étudiés par les pédologues belges au Ruanda-Urundi.

CLASSE IX : SOLS HALOMORPHES

Les Sols de la Classe Halomorphe sont dominés, dans leur évolution, par la présence et l'action de sels solubles ou des ions qui en proviennent. Les uns possèdent une teneur élevée en sels solubles, principalement chlorures et sulfates, parfois carbonates, de sodium, potassium, magnésium, calcium; les autres présentent une structure massive de l'un au moins de leurs horizons, due à sa richesse en ions sodium ou potassium, et dans certains cas, magnésium, adsorbés.

Cette influence dominante a été reconnue, jusqu'à présent, pour des teneurs en sels solubles correspondant à une conductivité de l'extrait de pâte saturée au moins égale à 4 millimhos par cm à 25°, et à une proportion d'au moins 12 à 15 p. 100 de Na + K échangeables par rapport à la capacité d'échange du complexe absorbant. En fait, cette seconde valeur dépend largement de divers caractères du sol et, en particulier, du type d'argile constituant son complexe, ainsi que de son état de saturation par les divers ions, et pas seulement par les ions alcalins. La première valeur est, aussi, très discutée; elle est regardée comme trop faible par de nombreux pédologues, en particulier d'Afrique du Nord. Le chiffre de 7 millimhos paraît être, dans bien des cas, la limite au-dessus de laquelle la salure devient la caractéristique essentielle du sol.

1) Dans une première sous-classe, sont placés tous les Sols Halo-

morphes à structure non dégradée par les ions alcalins; ce sont les Sols Salins. Ce groupe est subdivisé en deux sous-groupes, en fonction de la friabilité ou de l'induration de l'horizon superficiel : Sols Salins Modaux, friables en surface, et Sols Salins à surface encroûtée.

2) Les Sols Halomorphes à structure dégradée forment une deuxième sous-classe, celle des Sols à alcali.

a) Un groupe comprend tous ceux qui ne sont *pas lessivés* en argile, à profil AC ou A(B)C. Ils se subdivisent au niveau des sous-groupes, en Sols Halomorphes non Lessivés à alcali, peu ou moyennement Salés, et Sols Halomorphes non Lessivés à alcali, très Salés, facilement reconnaissables à leur horizon superficiel complètement boueux lorsque humide (argile sodique dispersée) et poudreux dès que sec.

b) Le groupe des *Sols Halomorphes Lessivés à alcali,* dont le profil est du type ABC, comprend plusieurs sous-groupes, différenciés sur la base des caractères morphologiques de leurs horizons :

— sous-groupe Modal;
— Solonetz dont l'horizon B possède une structure en colonnettes formées de prismes à sommets arrondis;
— Solonetz Solodisés, présentant, en outre, une ligne de quelques centimètres, très blanchie au-dessus de ces colonnettes;
— Solods comportant un horizon A_2 très clair ou même blanchi au-dessus d'un horizon d'accumulation à structure prismatico-cubique.

L'horizon supérieur de ces sols est de plus en plus acide du Solonetz au Solod, cependant que leur horizon B reste basique dans tous les cas, avec un pH au moins égal à 9.

La présence de carbonate de soude ne définit pas de sous-groupe, mais des faciès et surtout des séries.

CLASSE X : SOLS HYDROMORPHES

La Classe Hydromorphe réunit tous les sols dont l'évolution est essentiellement caractérisée par l'effet d'un excès d'eau par engorgement temporaire de profondeur ou de surface, ou par présence ou remontée de nappe.

Les sous-classes y sont distinguées en fonction de l'intensité et de la durée de cette hydromorphie, qui correspondent à des variations dans les caractères pédoclimatiques du sol, et qui s'expriment par des teneurs et des types différents de matière organique.

1) Certains sols sont très organiques, *tourbeux*. Ils se forment en condition d'hydromorphie totale et permanente, et leur teneur en

matière organique est toujours supérieure à 30 p. 100 dans le cas des sols assez argileux et 20 p. 100 pour ce qui est des sols sableux. Cette matière organique très grossière présente des caractères tourbeux très accusés.

L'ensemble de ces sols de tourbe est divisé en Sols Tourbeux Oligotrophes et Sols Tourbeux Eu- ou Mésotrophes.

2) Dans la seconde sous-classe, la matière organique, encore abondante (toujours supérieure à 8-12 p. 100), n'est que semi-tourbeuse, plus évoluée et bien mêlée à la matière minérale. Elle est du type anmoor. Ils ne constituent qu'un groupe, celui des *Sols Humiques à gley,* ou *Sols Semi-tourbeux.*

Ces sols se forment sous l'effet d'une hydromorphie totale mais temporaire, dans des conditions de climat ou de milieu chimique ne favorisant pas une évolution très poussée de la matière organique (différence d'avec les Vertisols).

Les sous-groupes y sont les suivants :

— Sols Semi-tourbeux des régions littorales chaudes (action d'un excès de sels et d'un pédoclimat chaud);
— Sols Semi-tourbeux des régions littorales froides ou tempérées (action d'un excès de sels et d'un pédoclimat frais à froid au moins une partie de l'année);
— Sols Semi-tourbeux non salés à anmoor acide;
— Sols Semi-tourbeux non salés à anmoor calcique.

3) Les Sols Hydromorphes minéraux forment une troisième sous-classe dont les groupes correspondent à la présence de gley ou de pseudogley en surface ou en profondeur, par suite d'une action et de caractères variables du facteur d'hydromorphie.

a) Le groupe des *Sols à gley ou pseudogley de surface ou d'ensemble* comporte comme sous-groupes :

— les Sols Hydromorphes à taches dès la surface;
— les Sols Hydromorphes à nodules calcaires et à concrétions ferro-manganiques en surface;
— les Sols à hydromorphie d'ensemble, indurés en profondeur;
— les Sols Hydromorphes à horizon gris (réduit) de surface ou subsuperficiel;
— les Sols Hydromorphes dès la surface et Salés.

b) Dans un deuxième groupe, les phénomènes d'hydromorphie sont dus, essentiellement, à un engorgement (pseudogley) en profondeur. Seuls y sont rangés les sols dans lesquels ce caractère est nettement dominant par rapport à tout autre exprimant d'autres processus d'évolution (lessivage, rubéfaction, ferrallitisation, salure etc.).

On y distingue les sous-groupes suivants :

— Sols marmorisés — à taches, traînées et bigarrures — en profondeur;

— Sols à pseudogley à nodules et concrétions en profondeur.

Certains sols lessivés en argile et très hydromorphes en profondeur, pourraient former un troisième sous-groupe; ils sont plutôt classés comme Sols Lessivés (Classe VI).

c) Le troisième groupe est celui des *Sols Hydromorphes à action de nappe (gley), en profondeur.*

On y retrouve les deux sous-groupes habituels à taches et traînées, et à nodules et concrétions, mais dans un matériau réduit dans son ensemble; et un troisième : Sols à croûte — calcaire ou gypseuse — ou à carapace ou cuirasse de nappe.

Un dernier sous-groupe y est constitué par les Sols à gley de profondeur et lessivés, souvent appelés Sols Lessivés à gley profond, ou encore Sols Gris Lessivés des bas-fonds.

⁂

Cette classification déjà très complexe, et que l'on essaie de rendre applicable à l'échelle mondiale, doit évoluer encore. Elle doit surtout, en bien des points, être précisée quant aux limites et aux définitions de ses diverses unités; elle peut aussi être sensiblement modifiée quant au groupement de ses divers éléments de base en catégories supérieures, en particulier pour ce qui est des sols peu évolués et des sols hydromorphes; elle doit enfin être complétée par de nouveaux sous-groupes correspondant à des sols insuffisamment étudiés ou non encore connus; et d'une façon plus générale, par l'adjonction de catégories correspondant, par exemple, à certains sols jeunes qui ne peuvent pas être décrits comme peu évolués, et qui, cependant, ne peuvent être encore que difficilement inclus dans les autres classes.

De in Frankrijk gebruikte bodemklassifikatie

Besluit

Deze reeds komplexe klassifikatie, die men zal trachten toepasselijk te maken op wereldschaal, moet nog evolueren. Ze moet vooral op talrijke punten gepreciseerd worden voor wat betreft de grenzen en de definities van haar verschillende eenheden. Ze kan eveneens gevoelig gewijzigd worden door de groepering van de diverse basiselementen in hogere kategorieën, vooral bij de weinig ontwikkelde en bij de hydromorfe bodems. Ten slotte moet ze aangevuld worden met nieuwe subgroepen voor de nog onvoldoend bestudeerde of nog onbekende bodems, en over het algemeen met het invoeren van nieuwe kategorieën b.v. voor sommige recente bodems die nog niet als weinig ontwikkeld kunnen beschouwd worden en die moeilijk bij de andere klassen kunnen gevoegd worden.

The soil classification used in France

Conclusion

The general idea is to make this rather complex classification ready for use at a universal scale; to obtain this goal however the system has still to evoluate. More especially it should become more precise with regard to the limits and the definitions of its various units. It may also be considerably changed by the grouping of the various basic elements in higher categories, especially for the weakly developed and the hydromorphic soils. Finally it has to be completed wih new subgroups for the insufficient studied or still unknown soils. New categories e.g. for some recent soils that cannot be considered as being weakly developed and that can difficultly be grouped with the other classes, should be introduced.

Die in Frankreich gebrauchte Bodenklassifikation

Konklusion

Diese schon sehr umfassende Klassifikation, die man versuchen wird der Weltskala anzupassen, muß sich noch weiterentwickeln. Vor allem soll sie in manchen Punkten, hinsichtlich der Grenzen und Definitionen der verschiedenen Einheiten, präzisiert werden. Sie kann ebenfalls erheblich geändert werden durch die Eingruppierung der diversen Basiseinheiten in höhere Kategorien, besonders bei den schwach entwickelten und den hydromorphen Böden. Schließlich soll sie durch neue Subgruppen für die noch ungenügend erforschten oder noch unbekannten Böden, und im allgemeinen durch die Einführung von neuen Kategorien (z.B. für einige rezente Böden), die noch als wenig entwickelt betracht werden können und die man schwer den anderen Klassen einfügen kann, ergänzt werden.

DISCUSSION(*)

G. D. Smith

1. All of the classes are indicated as having an (A) or A horizon. How do you classify truncated soils that may have only a B and C horizon ?

Chaque fois que possible (comparaison avec des sols voisins à profil complet, sur même matériau originel) le sol est alors rapporté au groupe auquel il appartiendrait. s'il n'était pas érodé, mais comme un sous-groupe particulier si l'érosion à été très forte, ou, plutôt, comme une série définie par ce phénomène d'érosion. Si une partie seulement de l'horizon A est enlevé, le sol est interprété comme une simple chose. Si ce « rapprochement » n'est pas possible, on classe le sol directement d'après ses caractères visibles. Lorsque l'érosion a été si forte que tout le sol est pratiquement enlevé et qu'il n'existe plus qu'un horizon A nouvellement formé reposant directement sur C, le sol est classé comme sol peu développé d'érosion (classe II).

2. It has seemed to our staff that we have been misled by our methods of analyses about the essential difference between the free sesquioxides of the Podzols and of the ferruginous tropical soils. Both may show large amounts of free sesquioxides. Yet base exchange capacities of the tropical soils are low, but in the Podzol B they are high.

The clays of the Podzol B horizons have high exchange capacities, 80-100 m.e. per 100 grams of clay, give little or no X-ray pattern, and yield large amounts of SiO_2 in dilute alkali. They also give DTA patterns similar to allophane. All indications are that it is not the accumulation of free sesquioxides that makes the B of the Podzols, but the accumulation of an amorphous clay, resembling the allophane of soils from volcanic ash.

E. Mückenhausen

1. Ich möchte Herrn Prof. Aubert fragen ob « sols lessivés à gley de profondeur » (Classe X) und « gray hydromorphic soils » der Tropen das gleiche sind.

Oui, c'est la même chose.

2. In welcher Kategorie stellen Sie die Böden der breiten Täler mit stark schwankendem Grundwasser, die wir « Aueböden » nennen ?

Si ces sols sont fortement gleyifiés, dans la Classe X. sous-classe 2; s'ils sont faiblement gleyifiés, dans la Classe II.

R. Tavernier

1. Avez-vous élaboré des définitions précises pour les horizons majeurs ?

Nous utilisons comme éléments « diagnostiques » la succession des horizons et la position du profil dans le paysage plus que les horizons eux-mêmes. Nous cherchons à préciser les caractères des horizons dans chacun de ces ensembles. Nous ne pensons pas atteindre une précision aussi poussée que le font nos collègues américains; elle nous paraît dangereuse, à la fois parce que certains caractères (pH, rapport d'humification, taux des éléments échangeables etc.) varient très largement au cours d'une même année, et parce qu'elle amène à séparer des sols très voisins dont seulement un horizon, le supérieur par exemple, diffère.

(*) Les réponses du Prof. G. Aubert aux questions et commentaires sont imprimées en caractères *italiques*.

2. Classe X : hydromorphe.

Quelles sont les limites entre les sols de la classe X et les sols à hydromorphie d'autres classes, p. ex. pour le groupe 2.C (sols à pseudogley de profondeur) ?

Dans de tels cas la classification du sol dépend de l'intensité des caractères hydromorphiques; si ces caractères sont très prononcés et masquent tous ceux provenant d'autres processus, ils seront placés en classe X; sinon ils le seront comme sous-groupes des groupes auxquels leurs autres caractères les rattachent.

3. Comment classez-vous les podzols humiques (*sans* fer) ?

Si ces podzols existent, ils doivent être classés comme sous-groupes du groupe des podzols, mais cela nous amènera à revoir la définition de la classe à laquelle ces sols appartiennent.

4. La définition de la classe VII ne me semble pas satisfaisante parce qu'elle omet de signaler la migration du fer et la présence de gels amorphes.

Il n'est pas possible de faire intervenir la migration des oxydes et hydroxydes de fer dans la définition de la classe VII; les sols ocre-podzoliques ne présentent pratiquement pas de migration de ces colloïdes. Je n'ai pas de renseignements sur la présence de ces gels amorphes.

C. Sys

I have to draw the attention to the fact that the color of tropical soils has to be interpreted with regard to at least three genetic factors: time, parent rock and topography.

On the same parent rock in equal topographic positions red and yellow colors become more intense with the progressing of weathering. The recent soils are reddish brown or brown with a Munsell chroma/value of 4/4 or lower. Highly weathered soils have stronger chromas and also higher values; at the different hues they present a chroma/value of 5/6 or 5/8.

At the same stage of weathering and the same topographic level the color of tropical soils has to be interpreted with regard to differences in parent material. For mature profiles red soils are characteristic on basic rock, limestone, dolomite; soils of a more yellow tone are observed on shales, sandstones and other silicious rocks.

In a typical landscape, on a specific parent rock, particularly on the African tertiary surfaces, the soil color seems to be connected with the internal drainage. Red plateau soils have a very deep water table; on the well drained slopes the water table comes nearer to the surface and the soils present a yellowish color; finally gray soils are observed in the waterlogged depressions. In this typical catena the transitional profile between well drained and hydromorphic soils presents an almost typical textural B horizon with additionnal presence of soft iron oxide concretions which become hard when dry. This profile with low base saturation seems to be related to the Red and Yellow Podzolic soils of America and the « sols ferrallitiques lessivés » of the French classification. The « sols ferrugineux tropicaux lessivés » have a high base saturation and therefore the characteristics of base saturation may be a criterion to separate Red-Yellow Podzolic soils from « sols ferrugineux tropicaux lessivés ». Red-Yellow Podzolic soils and the similar « sols ferrallitiques lessivés » seem to be the typical profile for wet subtropical areas, and of some tropical sites where the profile becomes alternatively very dry and very wet. The « sols ferrugineux tropicaux lessivés » seem to be typical profiles for dry areas.

For the rest it seems more difficult to find morphological criteria to separate the « sols ferrugineux tropicaux lessivés » from the « sols rouges méditerranéens lessivés ».

Il est en effet bien connu qu'en de nombreux cas les différences de couleur des sols ferrallitiques sont en relation avec leur profil hydrique. La chaîne de sols indiquée par M. Sys a été souvent étudiée en Afrique Occidentale depuis 15 ans.

Il est exact aussi qu'en d'autres cas cela provient de différences dans le matériau originel et dans la teneur en oxydes de fer libres (études faites à Madagascar).

Par contre, en d'autres sols nous ne savons pas à quelles variations dans les processus de formation des sols correspondent ces différences de couleur (en particulier dans le cas de sols à horizon jaune sur horizon rouge).

Pour ce qui est des sols ferrallitiques lessivés et sols ferrugineux tropicaux lessivés, je ne suis pas complètement d'accord avec M. Sys, en ce sens que les sols ferrugineux tropicaux lessivés correspondent à des climats tropicaux humides. Ils passent progressivement, mais sous de faibles variations pluviométriques, aux sols faiblement ferrallitiques. Les « Red and Yellow Podzolic soils » semblent beaucoup moins profondément altérés que les sols ferrallitiques lessivés.

F. Mancini

Je suis naturellement intéressé aux sols bruns méditerranéens. Mon avis est qu'il faut les placer dans la classe VI en prévoyant une sous-classe des « sols à mull des pays méditerranéens ». On pourrait encore distinguer deux groupes, c.-à-d. « sols bruns méditerranéens non lessivés » et « sols bruns méditerranéens lessivés » respectivement avec un (B) et un B textural.

Le passage de ces sols à ceux à mull des pays tempérés et des pays tropicaux est graduel et si l'on consulte des cartes climatiques, phytogéographiques et même pédologiques, on voit que la limite de la région méditerranéenne varie considérablement selon les différents auteurs.

Mais il y a sans doute une zone méditerranéenne à été humide, d'extension limitée, mais située tout près de la mer, par exemple en Turquie septentrionale. La pluviosité est forte, pouvant atteindre 2000 mm; la flore est nettement mésophile et ressemble beaucoup à celle de la période Riss-Würmienne de l'Europe centro-méridionale. Les sols, décrits par Oakes et les collègues de la Turquie, sont à placer dans la classe VIII. J'appellerais alors la première sous-classe « sols méditerranéens à sesquioxydes » plutôt que « sols rouges méditerranéens », parce que la présence de sols de type « Braunlehm » et de sols jaunes est très probable. Tous ces sols à sesquioxydes sont à considérer comme très proches des « Krasnozems » des auteurs russes.

Je ne peux que remercier M. Mancini de tous ces renseignements. Je suis d'accord avec les suggestions qu'il fait.

B. W. Avery

1. I would ask Prof. Aubert whether climatic criteria were used in differentiating soils of classes VI & VIII, or whether the separation was based on morphological characteristics. What is the place in the classification of leached soils resembling Red-Yellow Podzolic soils, which occur in association with highly weathered deposits and older land surfaces in cool temperature regions of both western Europe and North America ?

La séparation entre les classes VI et VIII est d'ordre morphologique. Elle correspond d'ailleurs à des différences de climat.

Les intermédiaires sont parfois difficiles à classer, par exemple certains sols de la région méditerranéenne.

Une autre difficulté peut surgir, en effet, lorsque des sols de la classe VI se sont formés sur des matériaux pédologiques fossiles correspondant aux sols de la classe VIII. D'après l'expérience que nous en avons, par exemple à la suite de l'étude de sols de Normandie ou de Bretagne, les caractères morphologiques des horizons supérieurs (en général sur environ 50 cm) sont bien différents dans les sols de ceux que l'on observe sur les sols de la classe VIII eux-mêmes : nature de la matière organique, liaison avec les éléments minéraux (argile par exemple), couleur, structure. Les sols sont alors classés dans la classe VI et la présence du matériau d'origine pédologique ancienne intervient dans la définition de la famille.

2. Concerning the group of « sols ocre-podzoliques », the iron oxides in the ochreous B horizons of these soils may result from weathering *in situ* rather than from illuvial accumulation.

Je suis tout à fait d'accord sur ce point. D'ailleurs la définition de la classe à hydroxydes et humus grossier ne fait pas intervenir le processus de lessivage.

J. W. Muir

1. Would Prof. Aubert give the profile designation (ABC etc.) for Class X (Hydromorphie) ?

There are a number of profile designations within the class, for example AG, ABgC, A(B)GC, etc.

2. Some Scottish podzols have B horizons which do not show the presence of illuvial Fe_2O_3.

Je suis d'accord; les sols ocre-podzoliques ont aussi cette particularité.

Cahiers O.R.S.T.O.M. — Série Pédologie — 1965, III, n° 3.

ANNEX IV - B

CLASSIFICATION DES SOLS

Tableaux des Classes, Sous-Classes, Groupes et Sous-Groupes de Sols utilisés par la Section de Pédologie de l'O.R.S.T.O.M. (1965)

par

G. AUBERT

d'après G. AUBERT et Ph. DUCHAUFOUR : Projet de Classification des Sols
C.R. VIè Congr. int. Sc. Sol.
PARIS 1956. D, 597 - 604

" G. AUBERT : La Classification des Sols
Cahiers ORSTOM - Pédologie, 3,
1963, 1 - 7.

" G. AUBERT : La Classification des Sols utilisée par les pédologues français en zone tropicale ou aride.
Sols Africains. 1964, IX, 1, 97-106.

" G. AUBERT : La Classification pédologique utilisée en France - Pédologie - à paraître 1966.

L'établissement de ces tableaux n'a été réalisé que pour des raisons d'utilisation pratique. Ils devraient paraître dans l'article de "Pédologie" prévu pour 1965 et non encore publié.

Nous avons pu profiter pour cette mise au point de discussions avec de nombreux collègues, en particulier dans le cadre du groupe de cartographie des sols de France (moyenne échelle). A la suite des travaux de ce dernier groupe, diverses modifications nouvelles seront d'ailleurs apportées ultérieurement à ces tableaux.

CLASSE II - SOLS PEU ÉVOLUÉS (on a aussi proposé : "peu Différenciés")

Sols à profil A.C ; A peu épais ou pauvre en matière organique ; degré d'altération des minéraux peu différent en A et en C.

SOUS-CLASSE 1. - SOLS PEU ÉVOLUÉS D'ORIGINE CLIMATIQUE

Pédoclimat froid, ou assez froid et très humide, ou sec pendant la plus grande partie de l'année, limitant l'évolution du sol.

GROUPE a. - TOUNDRAS

Sols gelés pendant une grande partie de l'année, humus en général peu évolué.

GROUPE b. - RANKERS

Sols riches en matière organique, passage brutal de A à C.

SOUS-GROUPES PROPOSÉS : RANKERS ALPINS
RANKERS ATLANTIQUES
RANKERS TROPICAUX

GROUPE c. - SOLS SUBDÉSERTIQUES

Sols à profil, en général, peu épais ; matière organique en faible quantité, mais diminuant progressivement en profondeur ; teneur en calcaire pratiquement constante ; complexe absorbant saturé.

Très souvent la surface est un peu durcie sur quelques centimètres et enrichie en éléments solubles.

SOUS-GROUPES :

SOLS SUBDÉSERTIQUES MODAUX

SOLS SUBDÉSERTIQUES FAIBLEMENT SALÉS OU ALCALISÉS

SOLS SUBDÉSERTIQUES EOLISÉS PAR DÉFLATION

SOLS SUBDÉSERTIQUES EOLISÉS EN MICRODUNES

SOUS-CLASSE 2 - SOLS PEU ÉVOLUÉS D'ORIGINE NON CLIMATIQUE

Sols jeunes ou rajeunis, mais dont le pédoclimat permet l'évolution du sol.

GROUPE a. - SOLS PEU ÉVOLUÉS D'ÉROSION

Sols peu épais formés sur pente, à matière organique généralement assez évoluée.

SOUS-GROUPES :

SOLS LITHIQUES, sur roches impénétrables aux racines ;

SOLS RÉGOSOLIQUES (on peut dire aussi SOLS RÉGIQUES ou SOLS RÉGOLIQUES)

RENDZINES ENCROÛTÉES , comportant au sommet de l'horizon C de nombreux nodules calcaires ou un encroûtement calcaire d'au moins quelques centimètres d'épaisseur.

RENDZINES DÉGRADÉES , à horizon profond plus riche en composés ferrugineux.

SOLS BRUNS CALCAIRES , à structure de type polyédrique ou prismatique au moins en (B).

SOLS BRUNS CALCAIRES HYDROMORPHES OU VERTIQUES analogues aux précédents, mais présentant une structure élargie en (B) et une couleur relativement foncée.

Un troisième groupe a été proposé :

SOLS ALLUVIAUX CALCIMORPHES

SOUS-GROUPES :

MODAL

VERTIQUE

Précédemment était reconnu un GROUPE c : RENDZINES DOLOMITIQUES ou MAGNESIENNES comprenant deux sous-groupes : Rendzines Dolomitiques Vraies et Rendzines Dolomitiques Dégradées. La différenciation entre rendzines calcaires et rendzines dolomitiques ou magnésiennes paraît pouvoir être faite de préférence au niveau de la famille.

Le problème de la classification des Sols rendziniformes non calcaires n'a pas été résolu définitivement. Ceux-ci sont actuellement indiqués parmi les Sols Bruns à Mull des régions tempérées.

SOUS-CLASSE 2 - SOLS à ACCUMULATION GYPSEUSE

L'accumulation gypseuse est due à une évolution pédologique des cristaux de gypse sans action d'une nappe phréatique.

GROUPE à ACCUMULATION GYPSEUSE LOCALISÉE

SOUS-GROUPES :

à ENCROÛTEMENT GYPSEUX , encore friable

à CROÛTE GYPSEUSE DURE

CLASSE V - SOLS ISOHUMIQUES

Sols à profil A C ou A (B) C, à teneur régulièrement décroissante en matière organique bien évoluée ; horizon humifère notable sur au moins la moitié du profil et sur plus de 50 cm (épaisseur ramenée à 30 cm pour les sols de profil < 50 cm).

SOUS-CLASSE 1. - SOLS ISOHUMIQUES à COMPLEXE PARTIELLEMENT DÉSATURÉ

Sols à structure polyédrique fine presque dès la surface.

GROUPE DES BRUNIZEMS

SOUS-GROUPES :

BRUNIZEM MODAL

BRUNIZEM à B TEXTURAL

BRUNIZEM à PSEUDOGLEY

BRUNIZEM VERTIQUE, à (B) de structure élargie et prismatique.

BRUNIZEM ENCROÛTÉ présentant un encroûtement calcaire formé en place au sommet de C.

BRUNIZEM à ALCALI OU à TENDANCE SOLONETZIQUE

SOUS-CLASSE 2. - SOLS ISOHUMIQUES à COMPLEXE SATURÉ (principalement en Ca) évoluant sous un pédoclimat très froid pendant une partie de l'année.

Sols à teneur en matière organique relativement élevée. Très forte activité de la faune du sol.

GROUPE a. - CHERNOZEMS

Sols à teneur en matière organique supérieure à 5% sous végétation naturelle sur au moins 20 cm ; structure grenue à nuciforme sur l'ensemble du profil ; horizon supérieur non ou très peu calcaire, même sur roche mère calcaire.

SOUS-GROUPES :

CHERNOZEM TRÈS HUMIFÈRE ; teneur en matière organique supérieure à 10% sur 20 cm.

CHERNOZEM MODAL

CHERNOZEM PEU PROFOND ; profil de 60 cm au plus et, en même temps, peu humifère.

CHERNOZEM à B TEXTURAL

GROUPE b. - SOLS CHÂTAINS OU CASTANOZEMS

Sols à teneur en matière organique de 3 à 6% sur 20 cm sous végétation naturelle ; structure grumeleuse à nuciforme dans l'horizon supérieur et prismatique en dessous.

SOLS CHÂTAINS SUBTROPICAUX à GLEY OU PSEUDOGLEY présentant des taches ou des concrétions ferrugineuses.

SOLS CHÂTAINS SUBTROPICAUX ENCROÛTÉS, à encroûtement calcaire en profondeur.

SOLS CHÂTAINS FAIBLEMENT ALCALISÉS (OU SALÉS).

GROUPE b. SOLS BRUNS SUBTROPICAUX

Sols à teneur en matière organique de l'ordre de 0, 8 à 1, 8% sous végétation naturelle ; structure grumeleuse à nuciforme dans l'horizon supérieur (parfois lamellaire en surface) mais polyédrique moyenne à fine (en général) dans l'horizon profond.
Décarbonatation partielle de la partie supérieure du profil, lorsqu'il est formé sur un matériau calcaire ou très calcique ; accumulation du calcium à assez faible profondeur (sauf sur matériau très perméable).

SOUS-GROUPES comme dans le groupe précédent.

GROUPE c. - SIEROZEMS (SUBTROPICAUX)

Sols à teneur en matière organique faible (moins de 1% sur 20 cm sous végétation naturelle, mais pouvant être plus élevée sous culture) ; décarbonatation réduite du profil sur matériau calcaire ; structure de même type que dans le groupe précédent, mais en général moins développée.

SOUS-GROUPES :

SIEROZEMS MODAUX
SIEROZEMS ENCROÛTÉS
SIEROZEMS FAIBLEMENT ALCALISÉS (OU SALÉS)

SOUS-CLASSE 4. - SOLS ISOHUMIQUES à COMPLEXE SATURÉ (principalement en Ca), évoluant sous un pédoclimat chaud pendant la saison des pluies.

Sols à teneur en matière organique plus réduite, mais altération minérale plus forte que dans la Sous-Classe 2 ; individualisation plus poussée des sesquioxydes de fer.

GROUPE. - SOLS BRUNS SUBARIDES

SOUS-GROUPES différenciés comme précédemment en :

SOLS BRUNS SUBARIDES MODAUX
SOLS BRUN-ROUGE SUBARIDES
SOLS BRUNS SUBARIDES VERTIQUES
SOLS BRUNS SUBARIDES à PSEUDOGLEY
SOLS BRUNS SUBARIDES FAIBLEMENT ALCALISÉS (OU SALÉS)

Il a été proposé de faire des Sols Brun-rouge Subarides un groupe plutôt qu'un sous-groupe.

GROUPE b. - SOLS BRUNS

Sols à profil A C ou A (B) C ; migration d'argile pratiquement nulle, ou indice de lessivage compris entre 1/1, 4 et 1 ; B faiblement ou non différencié ; pas de A_2.

SOUS-GROUPES :

SOLS BRUNS FAIBLEMENT LESSIVÉS ; B visible, mais indice de lessivage compris entre 1/1, 1 et 1/1, 4 ou différence de teneur en argile inférieure à 4 - 5%.

SOLS BRUNS MODAUX, profil de texture pratiquement constante et à réaction voisine de la neutralité (pH > 6).

SOLS BRUNS ACIDES, réaction acide (pH < 6) au moins en (B) et C ; pH voisin de 6 en A.

SOLS BRUNS HYDROMORPHES présentant des taches, traînées ou même concrétions, dues à des phénomènes de pseudogley, à la base du profil.

SOUS-GROUPE PROPOSÉ :

SOL BRUN EUTROPHE OU CALCIQUE, à profil peu épais de type A C ou A (B) C, à structure fortement marquée, moyenne à fine, grumeleuse à nuciforme en surface, polyédrique en profondeur ; non calcaire, mais complexe saturé en calcium ; roche-mère calcaire.

SOUS-CLASSE 2. - SOLS à "MULL" DES PAYS TROPICAUX

Pédoclimat chaud et humide à la fois, au moins temporairement.

GROUPE. - SOLS BRUNS EUTROPHES TROPICAUX

Sols à humus doux bien lié à la matière minérale, assez abondant en A_1 ; structure nettement développée, grumeleuse à nuciforme en A, cubique à polyédrique moyenne en (B) ; complexe saturé en bases alcalino-terreuses ; réserve minérale altérable abondante ; couleur tendant au brun-rouge par suite des sesquioxydes de fer libérés.

SOUS-GROUPES PROPOSÉS :

MODAL

HYDROMORPHE VERTIQUE

FERRUGINISÉ

PEU ÉVOLUÉ

SOLS PODZOLIQUES à LESSIVAGE OBLIQUE, horizon A_2 cendreux, peu épais, situé sur une pente au bas de laquelle se trouve l'horizon d'accumulation, riche en sesquioxydes métalliques - surtout de fer - .

SOUS-GROUPE PROPOSÉ :

SOLS MICRO-PODZOLIQUES . Sols à caractère podzolique, sur quelques centimètres, apparaissant au sommet (dans les horizons A_1 et A_2) d'un Sol Lessivé.

GROUPE c. - SOLS OCRES PODZOLIQUES

Sols dépourvus d'horizon A_2 ;

SOUS-GROUPES :

MODAL, horizon A_1 aussi riche en fer libre que l'horizon (B).

LESSIVÉ, horizon B enrichi en fer libre par rapport à A.

GROUPE PROPOSÉ : SOLS CRYPTO-PODZOLIQUES. Sols présentant l'aspect d'un Ranker, mais déjà plus évolués par individualisation d'oxydes de fer.

SOUS-CLASSE 2. - SOLS à "MOR" ENRICHIS EN SESQUIOXYDES à HORIZON DE GLEY EN PROFONDEUR

Sols à horizon d'accumulation présentant, le plus souvent, une limite inférieure très nettement définie.

GROUPE a. - PODZOLS à GLEY

SOUS-GROUPES :

MODAL, à horizons A_0 et A_1 riches en humus brut et humus grossier ; horizon A_2 nettement cendreux et assez épais.

à ALIOS

GROUPE b. - PSEUDO-PODZOLS DE NAPPE

Sols à horizon A_2 très épais, très blanchi, peu cendreux ; accumulation humique et ferrugineuse due surtout à la concentration, par la nappe, dans une zone assez peu étendue, d'éléments entraînés d'une région plus vaste.

GROUPE c. - SOLS PODZOLIQUES à GLEY

Sols à horizon A_2 très blanchi, tendance cendreuse faible.

SOUS-GROUPES :

à TACHES, MARBRURES ET CONCRÉTIONS

à ALIOS

à FRAGIPAN.

SOUS-GROUPES PROPOSÉS :

MODAL

HYDROMORPHE à PSEUDOGLEY

VERTIQUE

SOUS-CLASSE 2. - SOLS FERRUGINEUX TROPICAUX

Ces sols sont très riches en sesquioxydes de fer individualisés répartis sur l'ensemble du profil, ou, le plus souvent, accumulés dans ses horizons inférieurs, caractérisés par leur couleur rouge, rouille ou ocre, et, souvent, par leur richesse en concrétions réparties sur une assez grande épaisseur.

Leurs minéraux argileux comprennent de l'illite en plus de la kaolinite. Ils ne comportent pas d'alumine libre. Leur complexe absorbant n'est que faiblement désaturé (S/T supérieur à 40%).

Leur structure est fréquemment dégradée en surface ; la compacité y est alors élevée.

GROUPE a. - SOLS FERRUGINEUX TROPICAUX NON OU PEU LESSIVÉS

Sols dont la teneur en colloïdes minéraux est approximativement constante sur tout le profil.

SOUS-GROUPES :

SOLS à TENEUR CONSTANTE EN SESQUIOXYDES DE FER

SOLS UN PEU LESSIVÉS EN COMPOSÉS DU FER — mais non en argile.

SOLS FERRUGINEUX TROPICAUX JEUNES, à ferrugination peu accentuée ; généralement peu épais.

GROUPE b. - SOLS FERRUGINEUX TROPICAUX LESSIVÉS

Sols présentant un ou plusieurs horizons B, enrichis à la fois en argile et en sesquioxydes de fer.

SOUS-GROUPES :

SANS CONCRÊTIONS.

à CONCRÊTIONS dans l'ensemble de l'horizon B ou au moins dans sa partie médiane.

HYDROMORPHE à taches et concrétions de pseudogley au sommet de B et souvent aussi à la base de A.

INDURÉ en carapace ou cuirasse, les éléments en ayant été essentiellement individualisés sur place.

GROUPE c. - SOLS FERRALLITIQUES LESSIVÉS

Sols très désaturés et présentant toujours une réaction plus acide en surface qu'en profondeur.

SOUS-GROUPES :

MODAL, sols seulement lessivés en bases et non en argile.

LESSIVÉ EN ARGILE, à horizon B caractéristique.

PODZOLIQUE à humus grossier et horizon A_2 très blanchi, plus ou moins cendreux.

LESSIVE INDURE en profondeur, en carapace ou en cuirasse.

LESSIVÉ HYDROMORPHE à taches et concrétions de pseudogley à la base de l'horizon A_2 et au sommet de l'horizon B.

GROUPE d. - SOLS FERRALLITIQUES HUMIFÈRES

Sols très riches en humus dans un horizon A assez épais (plus de 7 à 8% de matière organique bien évoluée sur au moins 20 cm). L'horizon humifère a une structure grenue à nuciforme très accusée.

SOUS-GROUPES :

SOLS FERRALLITIQUES BRUNS TRÈS ACIDES, très lessivés en bases ; valeur très basse de $\frac{SiO_2}{Al_2O_3}$; structure souvent en petits grains très arrondis.

SOLS FERRALLITIQUES BRUNS moyennement désaturés (degré de saturation $\neq 50\%$).

SOLS FERRALLITIQUES BRUN ROUGE nettement désaturés et très évolués.

SOUS-GROUPE PROPOSÉ :

SOLS FERRALLITIQUES HUMIFÈRES D'ALTITUDE, à horizon sombre en profondeur.

CLASSE IX - SOLS HALOMORPHES

Sols dont l'évolution est dominée :

1° - soit par la présence de sels solubles, dont la teneur élevée provoque une importante modification de la végétation ; la conductivité de leur extrait de pâte saturée est au moins supérieure à 4 millimhos/cm à 25° ; il a été proposé de remonter cette limite à 7 millimhos ; avec des conductivités comprises entre 4 et 7 millimhos, les sols seraient classés dans des sous-groupes - caractérisés par une faible salure ou alcalisation - de Groupes d'autres Classes.

2° - soit par la richesse du complexe absorbant d'un de leurs horizons en ions (Na, K, peut-être Mg) susceptibles de provoquer la dispersion de l'argile, et l'apparition d'une structure massive, diffuse et d'une compacité très élevée $\frac{Na + K}{T}$ est, en général, supérieur à 15%).

CLASSE X - SOLS HYDROMORPHES

Sols dont les caractères sont dus à une évolution dominée par l'effet d'un excès d'eau par suite d'un engorgement temporaire de surface, de profondeur ou d'ensemble ou par suite de la présence ou de la remontée d'une nappe phréatique.

SOUS-CLASSE 1. - SOLS HYDROMORPHES ORGANIQUES

Matière organique de type peu fragmenté et faiblement évolué, à structure spongieuse, constituant l'élément principal du sol : plus de 30% de matière organique totale si le reste du sol est de texture argileuse ; plus de 20% s'il est de texture sableuse ; et cela sur l'essentiel du profil, ou au moins sur 20 cm ; hydromorphie totale et permanente.

GROUPE. - SOLS TOURBEUX

SOUS-GROUPES :

SOLS TOURBEUX OLIGOTROPHES, dont le pH de l'horizon tourbeux est inférieur à 5, 5 (sur le terrain).

SOLS TOURBEUX EU- OU MÉSOTROPHES, dont le pH est supérieur à 7 ou compris entre, environ, 5, 5 et 7.

SOUS-CLASSE 2. - SOLS HYDROMORPHES MOYENNEMENT ORGANIQUES

Sols à matière organique évoluée, de type anmoor, supérieure à, ou de l'ordre de, 10% (matière organique totale) sur au moins 20 cm ; hydromorphie totale mais temporaire.

GROUPE. - SOLS HUMIQUES à GLEY (parfois dénommés "Sols Semi-Tourbeux").

SOUS-GROUPES :

SOLS HUMIQUES à GLEY, SALÉS, soit à pédoclimat chaud des régions littorales tropicales (sols de poto-poto), soit à pédoclimat frais ou froid (sols de polders).

SOLS HUMIQUES à GLEY à ANMOOR ACIDE

SOLS HUMIQUES à GLEY à ANMOOR CALCIQUE

SOUS-CLASSE 3. - SOLS HYDROMORPHES MINÉRAUX OU PEU HUMIFÈRES

Sols à matière organique totale inférieure à environ 10% sur au moins 20 cm, et, en général, inférieure à environ 4 - 5%.
L'hydromorphie s'exprime par des caractères de couleur (taches de composés réduits ou réoxydés après réduction) ou de redistribution d'éléments solubilisables : oxyde de fer et de manganèse (en milieu réduit), calcaire, gypse, etc. sur le premier mètre environ, ou, de façon intense, en profondeur (entre 1 et 2 m).