

Soils of the Çumra Area, Turkey

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Preface

Since 1964 the Department of Tropical Soil Science in the Agricultural University of Wageningen has co-operated with Turkish scientists in carrying out various soil investigations in the Great Konya Basin. All together 4 Wageningen staff members, 18 Dutch students and 4 Turkish students have assisted.

The intention of this project was to train Dutch and Turkish post graduates in soil science, to carry out research work both in the field and in the laboratory and to provide the Turkish Government with the results of all investigations. The results are of interest especially for planning further agricultural development in this region.

The most important part of the Great Konya Basin, the Çumra Area, was given preference. The present study covers this region; it was carried out by Ir P. M. Driessen and Ir T. de Meester, assisted by students. It represents an example of a semi-detailed soil survey. Reports on the general soil conditions of the whole Great Konya Basin and on some specific subjects will be published later.

The Department of Tropical Soil Science in the Agricultural University of Wageningen is greatly indebted to the Turkish authorities and soil scientists for their kind help and co-operation and for providing facilities. Special thanks are due to Mr Naki Üner, General Director of Topraksu in the Ministry of Village Affairs, Mr Mesut Özyüçur, Director of the Soil and Fertilizer Research Institute in the Ministry of Agriculture, and Messrs Dursun Çuhadarođlu and Şaban Ermiş, Directors of the Çumra Experimental Station for Irrigated Agriculture, and their officers.

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This is the first report in a series of studies on the soils of the Great Konya Basin. The complete series to be published by Pudoc, Wageningen, will consist of the following publications.

1. Driessen, P. M. and T. de Meester: Soils of the Çumra Area, Turkey (this report).
2. de Meester, T. (Ed.): Soils of the Great Konya Basin, Turkey (in preparation).
Part A: Reconnaissance soil survey.
Part B: Reports on special studies.
3. de Meester, T.: Lacustrine carbonatic soils of the Great Konya Basin, Turkey (in preparation).
4. Driessen, P. M.: Soil salinity and alkalinity in the Great Konya Basin, Turkey (in preparation).
5. Janssen, B. H.: Soil fertility of the Great Konya Basin, Turkey (in preparation).

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1. Introduction

1.1 General data

For agriculture one of the most important regions of Turkey is that around Konya, some 300 km south of Ankara, known as the Great Konya Basin. It has been an important wheat-producing region for several thousand years, it was one of the mainstays of food supply in the Roman Empire, and it still covers most of Turkey's need for wheat.

The climate of this basin is semi-arid, so water supply is limiting for crop production. An irrigation system was constructed in 1912, designed by Dutch engineers and built by a German firm (Hoeffelman, 1913). It uses water from one of the streams descending from the mountains surrounding the basin.

The Great Konya Basin is a large flat plain without any outlet drainage. This favours salinization, which is a major agricultural problem. Aridity, alkalinity, the great variety of soils and erosion are among the features making this region highly interesting for the study of agronomy and soils.

Development of agriculture, extension of irrigation, construction of adequate drainage for desalinization of the soil, and soil conservation are some intentions of the Turkish government. These tasks have been delegated to the Soil Survey Department (Topraksu) in the Ministry of Village Affairs, and the State Water Works (DSI) in the Ministry of Energy and Natural Resources.

In 1954 an Experimental Station for Irrigated Agriculture was established at Çumra, some 50 km south of Konya, to study the development of crops, land-use and new agricultural techniques. In addition, the Wind Erosion Camp at Karapınar, in the centre of the basin, studies soil conservation, whereas DSI studies ways of improving and extending the irrigation and drainage.

In 1954 a general soil map 1 : 800,000 of Turkey was completed by Oakes. It served as a basis for further reconnaissance. In 1962 hydrological researches were carried out by FAO, assisted by the International Institute for Land Reclamation and Improvement (IILC) in Wageningen; Kessler & de Ridder *et al.* published the results and recommendations in a report on water management in the irrigated area around the Village of Çumra (FAO Report No 1975). From these studies it became obvious that little information on soils was available.

The number of soil scientists in Turkey, though rapidly increasing, is still small, in spite of training courses held in several places (e.g. Tarsus). So the Turkish Government agreed to select some areas suitable for soil studies for the Agricultural University

of Wageningen and the Great Konya Basin was finally chosen. This choice was made not only because of the agricultural importance of this region and the variety and complexity of the problems to be solved, but also because the Turkish Government was very interested in this area and wanted more detailed information on aspects of the soil, such as location, salinity, alkalinity and fertility.

Within the Basin, the Çumra Area is most important. It contains very good soils, mainly irrigated. Much information was already available at the Çumra Experimental Station for Irrigated Agriculture, more research on its soils was necessary to make the most of the available data and to further develop this area. Therefore it was decided to make a more detailed survey of the Çumra map sheet within the scope of the Konya Project. This semi-detailed survey also favoured the reconnaissance survey of the whole Great Konya Basin, as most of the soil series studied also occur in other parts of the Basin.

The experimental station and many other government institutions studying, for example, crop control were able to set up some trials on the relation between crop and soil to classify the capabilities of the various soils.

In an Appendix to this report the soils of the Çumra Experimental Station are described in detail.

1.2 Scheme of the work

Because the Konya Project was educational, the Çumra Area was divided into ten subareas, each mapped by a post-graduate student (fig. 1). The work was supervised by Ir T. de Meester (in 1964 and 1965) and by Ir P. M. Driessen (in 1966 and 1967).

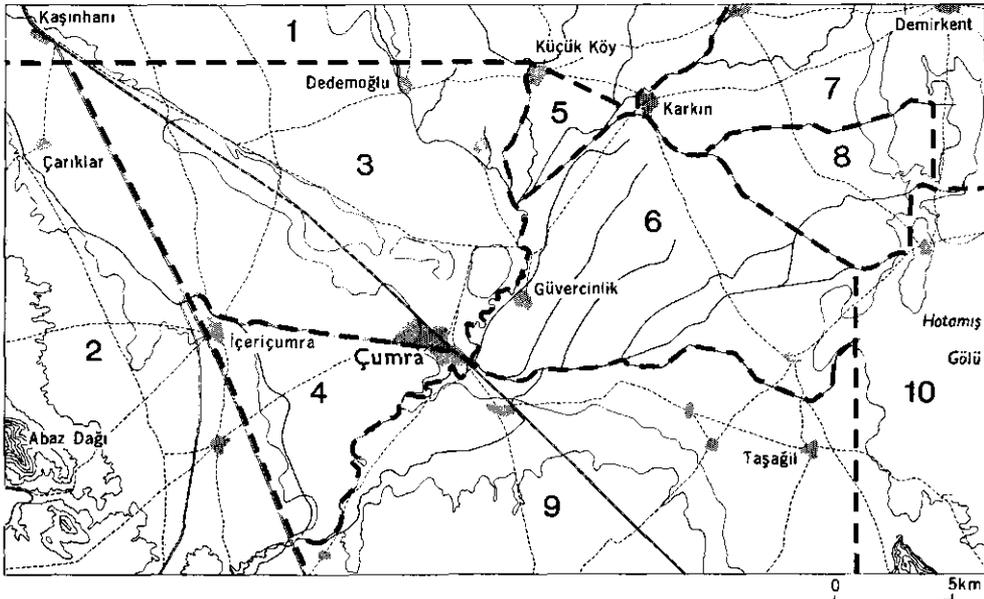
In their subareas the participants usually followed a certain working method. After a few days of general exploration physiographic units or landscapes were tentatively described. Next a preliminary soil survey map was drawn from stereoscopic aerial photographs (1 : 20,000). Except for a few defectively printed areas the quality of these photographs was good. Simultaneously the soils were tentatively classified and a key was made. The results were drawn in grease pencil directly onto the photographs. Next the ground survey was planned and a few small areas were selected for initial sampling. The map and key were amended after this fieldwork. Finally each mapping unit was checked for soil characteristics in the field and the limits of the units were definitely established.

During the field-work soil profiles were studied and borings were made down to a depth of 120 to 200 cm with an Edelman-type soil auger. At some sites borings were deeper (to a depth of 350 to 400 cm) to examine the subsoil.

In the sample areas the observation points were in straight lines at regular intervals. Outside these areas representative spots were selected for efficiency as possible. The observation points were exactly recorded onto the aerial photographs or onto a topographic map.

The main soil characteristics of the profiles, such as colour (according to the Munsell notation), texture, structure, porosity and mottling were recorded on the

Fig. 1. Division of the Çumra Area into subareas.



The subareas and their surveyers were:

1 Çumra north	Ir P. M. Driessen and W. van Vuure	6 Çumra centre	Ir P. M. Driessen and P. van Blom
2 Çumra west	H. L. Slothouwer and Ir T. de Meester	7 Çumra north-east	Ahmet R. Mermut
3 Çumra north-west	Kadir Gülcan	8 Çumra east	Gülağa Şimşek
4 Çumra south-west	C. C. Bannink and Ir T. de Meester	9 Çumra south	W. L. Peters and Ir T. de Meester
5 Karkın triangle	A. F. Groneman	10 Çumra south-east	Ir P. M. Driessen and W. van Vuure

Şekil 1. Çumra bölgesinin altarazi seviyesinde bölümü.

spot. Notes were made on specific features such as concretions and shells, on topography and land-use of the terrain at the observation points and of the terrain between them.

To study the soil profiles many pits were dug. Selected profiles were described in detail according to the scheme and instructions of the Soil Survey Manual (Handbook 18 of the United States Department of Agriculture). The diagnostic horizons were determined and carefully checked before the profile was classified. For this classification the 7th Approximation of the Soil Classification System of the US Soil Conservation Service and its 1964 and 1967 Supplements were used.

Soil samples were collected from each horizon for investigations on soil genesis at Wageningen. From some profiles samples were taken every 10 cm to study salinity and alkalinity. Their number was limited because they had to be transported to the Netherlands by Landrover.

As a rule a soil peel (de Meester & Bouma, 1967) was made from the important profiles sampled. Such soil peels appeared to be extremely useful for reference and they can be studied in a laboratory with a binocular microscope.

The information from field work and photo-interpretation was used to make a soil map 1 : 50,000. The result may be considered satisfactory: in general the error did not exceed 15% of the mapped surface of the various map units.

After checking the limits and, where necessary, amending the maps, they were reduced to the scale 1 : 100,000 as in this report. Besides its direct importance it may serve such purposes as planning irrigation, drainage and new roads. From this general map special ones may be derived, such as for land capability.

2. General description of the Çumra Area

2.1 Geography and geology

The Great Konya Basin forms parts of the Central Anatolian Plateau. It has an area of about 10,000 sq.km. It includes the plains of Konya, Çumra, Karaman, Karapınar, Ereğli and Bor and is enclosed by the Toros Mountains in the south and by the Anatolides in the north and west.

The Toros Mountains consist of upper cretaceous limestone, the Anatolides of Palaeozoic limestone and schists. Locally Upper Miocene volcanic material occurs. Tectonic movements during the tertiary period caused numerous faults, important for the occurrence of artesian water. At several places there are Neogene terraces.

During the Pleistocene (Würm) parts of the Basin floor were covered by a shallow lake, witnessed by cliffs and beachridges along parts of the Basin borders (Louis, 1938). The fairly constant level of this lake is clearly reflected by the position and level of these ridges. Gradually the lake filled with calcareous sediments. Later on it dried up and its shore lines moved towards the centre of the Basin. Meanwhile rivers from the surrounding uplands deposited on the flat shores fluvial coarse and medium textured sediments in various systems. The very fine components, if not deposited in local minor depressions, were washed towards the central parts of the Basin where they sedimented as heavy clay.

Parallel with the mountains 'bajadas' occur. They form a zone of fine material washed from the slopes of both volcanic and limestone mountains. This zone is Neogene or younger.

The whole geogenesis as described above is clearly recognizable in the Çumra Area: large parts of it consist of lacustrine calcareous sediments, locally covered by deposits of the rivers May and Çarşamba. Bajadas are found in the southern and eastern parts, whereas large tracts in the south are occupied by structural terraces.

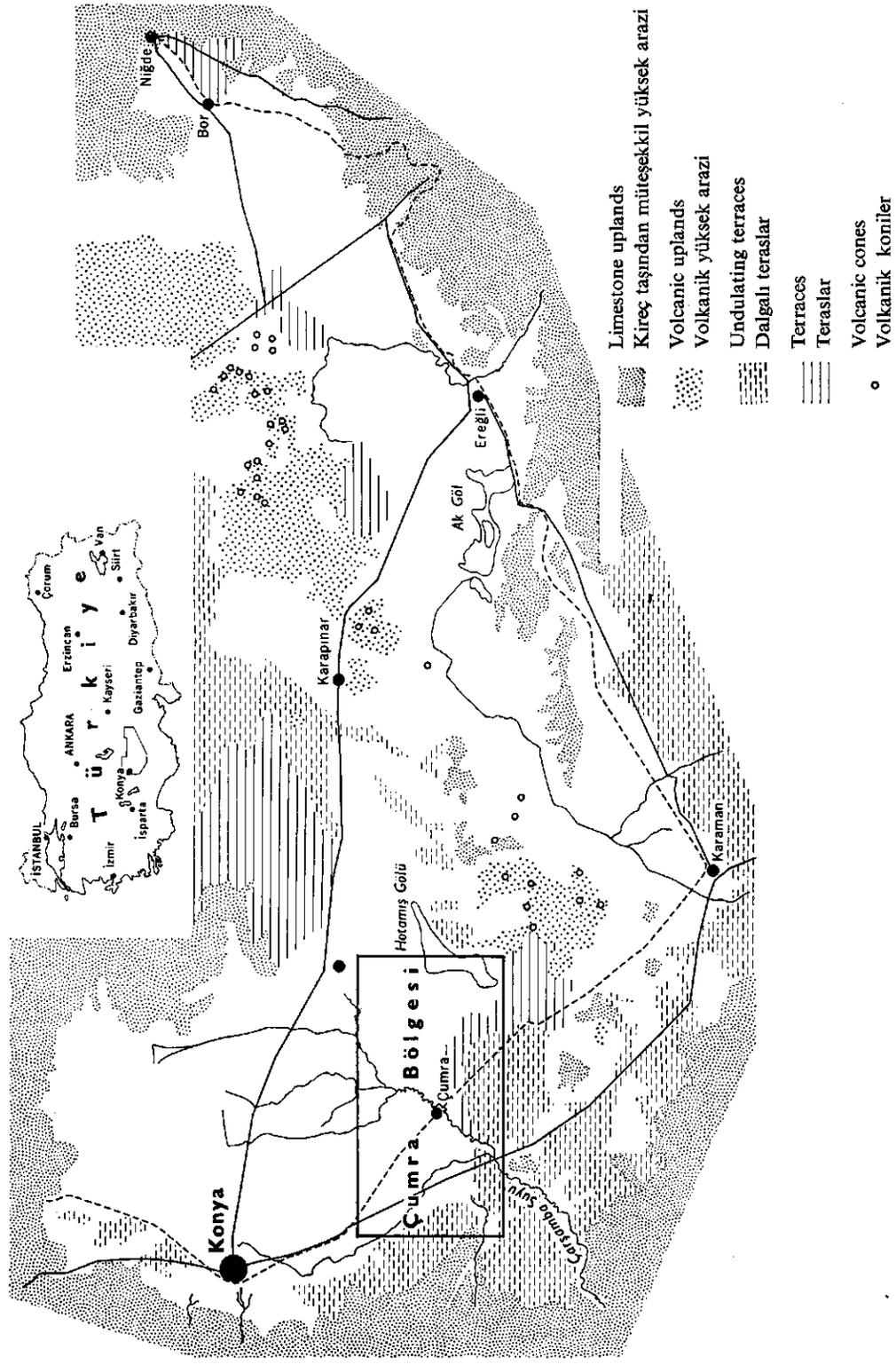
The Çumra Area (fig. 2) is almost flat, with a general slope from south-west (1020 m) to north-east (1002 m).

In the south the River Çarşamba enters the area, splitting up into three branches in the central part between the villages of Güvercinlik and Küçük Köy. All contain water throughout the year. The river May enters in the south-west; it dries up in summer.

The Çumra Area is well accessible by many roads and tracks, except for some swampy parts in the east. From north-west to south-east it is crossed by a railway.

Most of the population live in some 20 villages scattered all over the area. The

6 Fig. 2. Location of the Çumra Area.



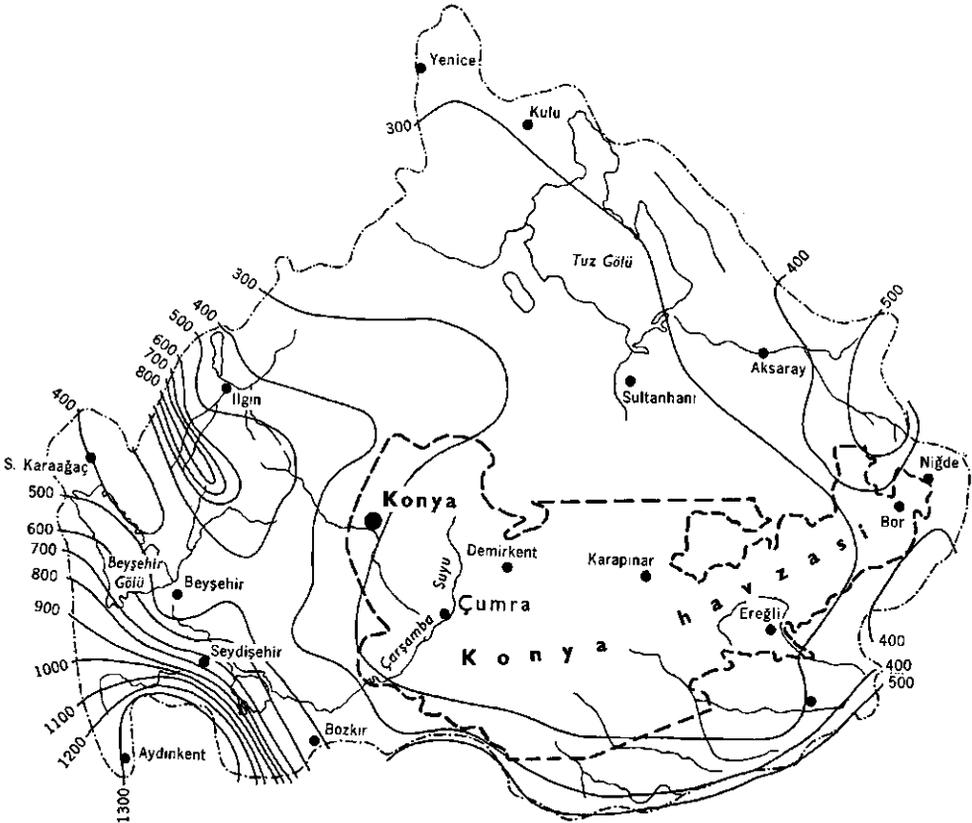
administrative and economic centre is the Village of Çumra on the River Çarşamba.

2.2 Climate

Due to differences in topography, the climate is not the same all over the Great Konya Basin (fig. 3). On a much smaller scale such differences are also present within the Çumra Area. Therefore a number of rainfall gauges have been installed by DSI in or close to the irrigated area. But because no long-range data are yet available, those supplied by the Çumra Experimental Station (table 1) have been used as a standard for classifying profiles in the whole area; they show the monthly distribution.

They indicate that the climate is semi-arid. A distinct dry and warm summer is followed by a cool and relatively wet winter. In general the annual rainfall does not exceed 250 mm; there is rarely any rainfall in July and August. Particularly in winter the rain falls in showers. In addition fig. 4 represents the frequency distribution of the

Fig. 3. Rainfall distribution in and around the Great Konya Basin.



Şekil 3. Büyük Konya Havzasında ve çevresinde yağış dağılımı.

Table 1. Mean climatological data for Çumra over the years 1954-1963.

	J/O	F/S	M/M	A/N	M/M	J/H	J/T	A/A	S/E	O/E	N/K	D/A	Total Yekün
Mean temperature °C / ortalama sıcaklık	1.4	2.1	5.9	11.3	16.1	20.3	23.5	22.7	17.5	12.7	6.9	2.9	
Rainfall mm / yağış	27.4	30.4	25.1	26.9	30.3	17.6	1.5	1.2	8.8	21.6	16.2	38.2	245.6
Number of rainy days ¹ / yağışlı günlerin sayısı	9	11	10	8	9	6	1	1	3	5	6	9	
Wind speed in m/s ¹ / rüzgâr hızı	1.8	2.0	2.2	1.9	2.0	1.8	2.1	2.0	1.8	1.4	1.4	1.9	
Open tank evaporation mm / açık havuz buharlaşması	5	14	43	99	138	116	199	189	136	75	25	9	1098
Relative air moisture % / nisbi hava nemi	82	77	73	64	62	58	53	54	62	63	76	83	

1. Three arbitrary years of the period 1954-1963 / 1954-1963 arasında gelisigizel üç sene.

Tablo 1. Çumranın 1954-1963 senelerinde ortalama iklim durumu.

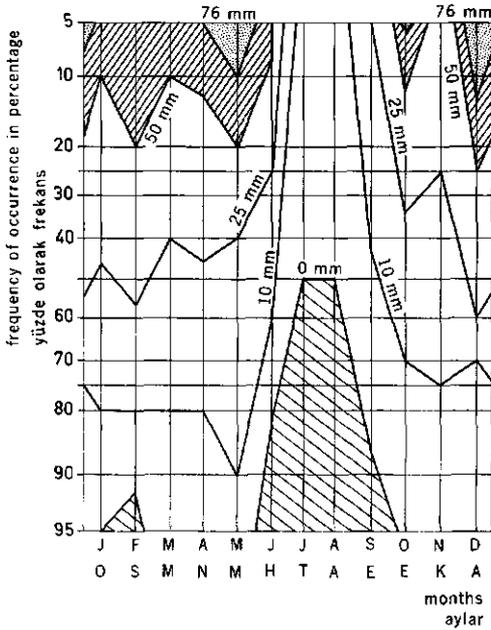


Fig. 4. Frequency distribution of the monthly precipitation at Çumra (30 years). Source: FAO Report 1965.

Şekil 4. Çumrada aylık yağışın dağılım teker-rürü (30 yıllık). Kaynak: FAO-Raporu 1965.

monthly precipitation as calculated by Kessler (1965) for Çumra.

The following remarks may be added. Winters are cold in the Great Konya Basin. In the Çumra Area temperatures as low as -25°C have been recorded. Nightfrosts may occur from early October until late April. In summer temperatures are high in the daytime but the nights are cool.

Relative humidity is low throughout the year. This partly explains the high evaporation (up to 6 mm/day). The steady wind, predominantly from northern directions, also contributes to these high values.

For agriculture it is very important whether the water content of the soil reaches field capacity at the beginning of the dry season, so that the success of a crop is very much influenced by the precipitation in May.

In the 1967 Supplement of the 7th Approximation climatic criteria are used to distinguish soils which have many characteristics in common, but occur in different climatic regions. In this classification it is essential to know whether the soil is dry for more or less than 60 consecutive or 90 cumulative days, and which are the mean annual soil temperatures at various depths both during summer and winter. The length of the observation period is also important, for some criteria can be used only if they apply to more than seven in ten years.

Data are still insufficient for such detailed considerations, but it should be stressed that without them no clear knowledge can be gained of the pedological conditions.

2.3 Hydrology

Management of irrigation by the farmers in the Çumra Area is generally poor. Heavy water losses from the higher fields and lack of drainage from the lower fields cause a high watertable in the lower parts of the area, thus introducing severe salinization of the soils there.

In the Çumra Area the irrigation water is supplied by the rivers Çarşamba and May.

The River May flows only in winter. Its annual discharge of about 70.10^6 m³ can be used only in winter and spring. So a barrage has been constructed to regulate and store the seasonal surplus for growing crops in summer, but karst phenomena in the reservoir have caused high losses and prevented proper functioning. This river is therefore of only minor importance for irrigation in the Çumra Area.

The River Çarşamba, with a catchment area of about 7650 km² and a yearly discharge in the Konya Basin of 400.10^6 m³ provides nearly all irrigation water. Near the Village of Apa, about 10 km south of the Çumra Area, a dam has been constructed to regulate and store water from this river. This water is of excellent quality. Analytical data from the project's field laboratory are remarkably similar to those from Kessler's publication and indicate an almost constant mineral content, as apparent from table 2. Moreover the electrical conductivity of water from the Çarşamba near Çumra estimated weekly for months (May till October 1967) was nearly constant, average 0.41 mmho/cm, corresponding with approximately 4.5 meq salts per litre.

Another, though less important type of irrigation is by pumping, which occurs at several places throughout the Great Konya Basin. In the Çumra Area the sandridge east of Kaşınhanı is irrigated in this way.

Losses in the canals and tributaries and on the fields have caused the Turkish authorities in charge of planning, construction and maintenance of the irrigation system to line many canals in the Çumra Area. Although this is certainly an important improvement many other improvements as in drainage are needed for proper functioning of the system.

Table 2. Mineral contents of irrigation water from the River Çarşamba.

	pH	Con. / geçirgenlik mmho/cm	Mineral contents in meq per litre / litrede meq mineral madde miktarı							
			Na	K	Ca + Mg	HCO ₃	Cl	SO ₄	CO ₃	Total ions yekün
12/7/62 ¹	8.0	0.45	0.50	0.25	3.70	3.58	0.40	0.31	0.16	4.70
16/7/64	7.9	0.40	0.64	0.20	3.59	3.73	0.26	0.21	0.43	4.70

1. From Kessler, *op.cit.* / Kessler'e göre.

Tablo 2. Çarşamba nehrinden alınan sulama suyundaki mineral madde muhtevisiyatı.

Though the Great Konya Basin as a whole has no surface drainage, local drainage is still possible, as in the Çumra Area. There the major canal leads to Lake Hotamış where the water evaporates.

As mentioned before, the whole area slopes from south-west to north-east. This means that part of the irrigation water supplied in the southern half of the Çumra Area causes a high watertable in the north, favouring salinization, so that the northern parts are among the worst recorded in the whole area. In spring pools on the surface are common.

The topography and the characteristics of the soil show that drainage in the south and west of the Çumra Area is much better than in the east and north.

2.4 Land types and soil associations

Land types are physiographic units. If adequately defined and classified, such units show specific ranges of geographically and genetically related soils, that can be considered soil associations.

In this report the land types and the corresponding soil associations have been indicated with the same name, though the symbols refer, strictly speaking, only to the latter (table 3).

In fig. 5 a sketch map is presented giving the location of the distinguished soil associations and of the miscellaneous land types. The general character of each soil association will be discussed in chapter 4.

Table 3. Land types and soil associations distinguished in the Çumra Area.

Land types	Soil associations
T Terraces	Te Flat terrace soils
	Th Undulating terrace soils
	Tg Terrace gully soils
A Alluvial plain	Ar Bajada soils
	Am May fan soils
	Ac Çarşamba fan soils
	Ab Former backswamp soils
L Lacustrine plain	Lc Soft lime soils
	Lm Marl soils
	Lr Ridge soils
	Lp Sandplain soils
M Miscellaneous land types	

Tablo 3. Çumra bölgesinde tesbit edilen arazi tipleri ve toprak birlikleri.

Fig. 5. Physiographic units distinguished in the Çumra Area.



Şekil 5. Çumra bölgesinde ayırt edilen fizyografik üniteler.

Legend for fig. 5.

- | | | |
|----|---|---|
| 1 |  | Bajada
Bajada |
| 2 |  | Flat terraces
Düz teraslar |
| 3 |  | Undulating terraces
Dalgalı teraslar |
| 4 |  | Gullies
Galiler |
| 5 |  | May fan
May çay yelpazesi |
| 6 |  | Çarşamba plain
Çarşamba çayı ovası |
| 7 |  | Former backswamps
Eskiden bataklıklar |
| 8 |  | Soft lime
Yumuşak kireç |
| 9 |  | Marl
Marn |
| 10 |  | Ridges
Kum bendiler |
| 11 |  | Sandplain
Kumlu ova |
| 12 |  | Miscellaneous land types
Çesitli arazi tipleri |

3. The soils

3.1 Classification and terminology

The complicated geogenesis of the Great Konya Basin has resulted in a considerable number of soil associations. Each soil association can be divided into soil complexes or soil series. The amount of detail required of the survey made it necessary that the series be mapped; in other words: a map unit represents in principle a soil series or a complex of such series. But often a further step could be made in mapping soil phases, so that the ultimate result may be said to have a semi-detailed character. This chapter describes them systematically.

The classification of the soils into series is not only based on pedogenetic characteristics like degree and depth of secondary lime segregation but also on differences in texture of surface, subsurface and subsoil, in colour and in topography. The phases are based on such characteristics as the depth of surface and subsurface, the drainage condition and the stoniness (see 3.2).

To illustrate the properties of the soils, detailed descriptions of one or more representative profiles have been added, where possible with chemical and physical analyses of soil samples and soil peels. Fig. 6 gives the location of the profiles studied and described in detail. The numbers on the map correspond with the profile numbers mentioned in the following chapters.

The terminology is in conformity with that used in the Soil Survey Manual. The classification and the nomenclature of the soils agree with those in the 7th Approximation.

The most common terms are the following:

Soil depth, independent of composition and origin:

surface soil	plough layer
subsurface soil	solum
subsoil	undisturbed soil

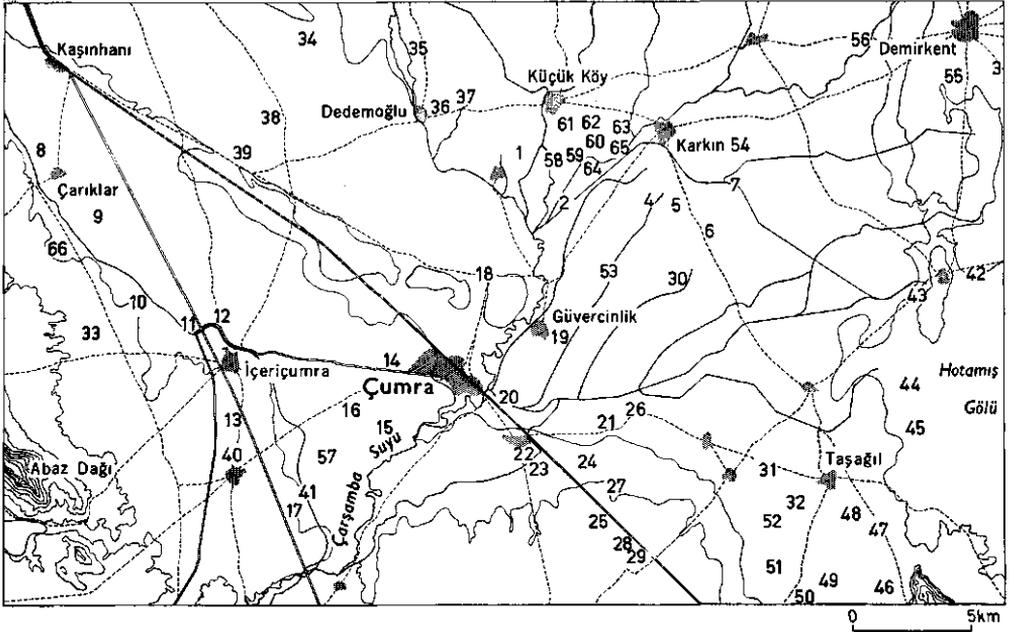
Soil depth relative to underlying material.

very shallow soils	<20 cm deep
shallow soils	20– 40 cm deep
moderately deep soils	40– 80 cm deep
deep soils	80–120 cm deep
very deep soils	>120 cm deep

Soil texture:

sandy soils:

Fig. 6. Location of the described profiles.



Şekil 6. İzahı yapılan profillerin yerleri.

sand	coarse-textured
loamy-sand	moderately coarse-textured
sandy-loam	moderately coarse-textured
fine-sandy-loam	moderately coarse-textured
loamy soils:	
loam	medium-textured
silt-loam	medium-textured
silt	medium-textured
clayey soils:	
clay-loam	fine-textured
sandy-clay-loam	fine-textured
silty-clay-loam	fine-textured
sandy-clay	fine-textured
silty-clay	fine-textured
clay	fine-textured
heavy-clay	fine-textured
Porosity:	
mesopores	soil pores 30–100 μm , visible at $\times 10$ magnification
macropores	soil pores $>100 \mu\text{m}$, visible with the naked eye.

3.2 Soil legend for the Çumra Area (key to the Soil-map)

T Terraces

Te Flat terrace soils

Te 1 Beylerce series, 1010 m level

Te 1.1 Beylerce clayey soil, deep

Te 1.2 Beylerce clayey soil, moderately deep

Te 1.3 Beylerce clayey soil, moderately deep, with reddish surface soil

Te 1.4 Beylerce loamy soil, deep

Te 2 Okçu series, 1020 m level

Te 2.1 Okçu clayey soil, deep

Te 2.2 Okçu loamy soil, deep

Te 3 Dinlendik series, 1025 m level

Te 3.1 Dinlendik clayey soil, deep

Te 4 Sevil series

Te 4.1 Sevil loamy soil, deep

Th Undulating terrace soils

Th 1 Yavşan series

Th 1.1 Yavşan loamy soil, often angular cobbly, deep

Th 1.2 Yavşan loamy soil, angular cobbly, moderately deep, over hard limestone

Th 1.3 Yavşan loamy soil, angular cobbly, shallow, over hard limestone

Tg Terrace gully soils

Tg 1 Arif series

Tg 1.1 Arif loamy and clayey soil, angular cobbly, gully bottom

Tg 1.2 Arif loamy and clayey soil, angular cobbly, gully slopes

A Alluvial plain

Ar Bajada soils

Ar 1 Dirabey series

Ar 1.1 Dirabey clayey soil, deep

Ar 1.2 Dirabey clayey soil, moderately deep over carbonate subsoil

Ar 2 Çarıklar series

Ar 2.1 Çarıklar clayey soil, moderately deep over lime

Am May fan soils

Am 1 Alibey series

Am 1.1 Alibey clayey soil, deep

Am 1.2 Alibey loamy soil, deep

Am 1.3 Alibey loamy soil, deep, stratified subsoil

Am 1.4 Alibey loamy soil, moderately deep over terrace soil

Am 2 İnli series

Am 2.1 İnli sandy soil, deep

Am 2.2 İnli gravelly sandy soil, deep

Am 2.3 İnli coarse sandy and gravelly soil, deep

Ac Çarşamba fan soils

Ac 1 Çumra series

Ac 1.1 Çumra clayey soil, deep

Ac 1.2 Çumra clayey soil, deep, imperfectly drained

Ac 1.3 Çumra clayey soil, deep, with heavy clayey surface soil, imperfectly drained

Ac 1.4 Çumra clayey soil, deep, over soft lime

Ac 1.5 Çumra clayey soil, moderately deep over soft lime

Ac 1.6 Çumra clayey soil, moderately deep over loam

Ac 1.7 Çumra clayey soil, moderately deep over heavy clay, imperfectly drained

Ac 1.8 Çumra loamy soil, deep

Ac 1.9 Çumra loamy soil, deep over coarse subsoil

Ac 1.10 Çumra loamy soil, deep over heavy subsoil

Ac 1.11 Complex of deep clayey and loamy soils, imperfectly drained

Ac 1.12 Complex of sandy soils, deep

Ab Former backswamp soils

Ab 1 Karkın series

Ab 1.1 Karkın heavy clayey soil, deep, moderately well drained

Ab 1.2 Karkın heavy clayey soil, moderately deep over carbonate subsoil

Ab 1.3 Karkın swelling heavy clayey soil, moderately deep over gypsiferous subsoil, poorly drained

Ab 1.4 Karkın clayey soil, deep, imperfectly drained

Ab 1.5 Karkın clayey soil, moderately deep over light subsoil, moderately well drained

Ab 1.6 Karkın loamy soil, moderately deep over clay or carbonatic clay

Ab 1.7 Karkın loamy soil, moderately deep over clay or carbonatic clay, poorly drained

Ab 2 Alemdar series

Ab 2.1 Alemdar heavy clayey soil, deep, moderately well to imperfectly drained

Ab 2.2 Alemdar heavy clayey soil, deep, poorly drained

Ab 3 Dedemoğlu series

Ab 3.1 Dedemoğlu clayey soil, moderately deep over lime or carbonatic clay, moderately well to imperfectly drained

Ab 4 Ovakavağı series

Ab 4.1 Ovakavağı heavy clay, deep, moderately well drained

L Lacustrine plain

Lc Soft lime soils

Lc 1 Ürünlü series, imperfectly drained

Lc 1.1 Ürünlü soft lime, moderately deep loamy surface soil

Lc 1.2 Ürünlü soft lime, shallow loamy surface soil

Lc 1.3 Ürünlü soft lime, shallow loamy surface soil, concretionary

- Lc 1.4 Ürünlü soft lime, shallow clayey surface soil
- Lc 2 Kaşınhanı series, moderately well drained
 - Lc 2.1 Kaşınhanı soft lime over limestone, moderately deep loamy surface soil
 - Lc 2.2 Kaşınhanı soft lime over limestone, shallow loamy surface soil
 - Lc 2.3 Kaşınhanı soft lime over limestone, very shallow loamy surface soil
- Lm Marl soils
 - Lm 1 Demirkent series
 - Lm 1.1 Demirkent carbonatic loamy soil, deep
 - Lm 1.2 Demirkent carbonatic loamy soil, deep, stratified subsoil
 - Lm 2 Serpil series
 - Lm 2.1 Serpil carbonatic soil, moderately deep, shallow clayey surface soil, poorly drained
 - Lm 3 Pınarbaşı series
 - Lm 3.1 Pınarbaşı carbonatic clayey soil, deep, imperfectly drained
 - Lm 3.2 Pınarbaşı carbonatic clayey soil, moderately well drained, angular cobbly
 - Lm 4 Süleyman Hacı series
 - Lm 4.1 Süleyman Hacı carbonatic clayey soil, deep, gypsiferous
 - Lm 5 Ahmet Hoca series
 - Lm 5.1 Ahmet Hoca silty clay, deep
- Lr Ridge soils
 - Lr 1 Fethiye series
 - Lr 1.1 Fethiye gravelly sandy soil, high phase
 - Lr 1.2 Fethiye gravelly sandy soil, low phase
 - Lr 1.3 Fethiye gravelly sandy soil, low and flat phase
 - Lr 2 Karaarslan series
 - Lr 2.1 Karaarslan gravelly sandy soil, low phase
 - Lr 2.2 Karaarslan gravelly sandy soil, low and flat phase
- Lp Sandplain soils
 - Lp 1 Sarlak series
 - Lp 1.1 Sarlak sandy soil, deep
 - Lp 1.2 Sarlak sandy soil, deep, imperfectly drained
 - Lp 1.3 Sarlak loamy soil, deep, moderately well drained
 - Lp 1.4 Sarlak loamy soil, finer subsoil, imperfectly drained
 - Lp 1.5 Sarlak loamy soil, complex with stratified subsoil
 - Lp 2 Güvercinlik series
 - Lp 2.1 Güvercinlik loamy soil, deep, imperfectly drained
 - Lp 2.2 Güvercinlik loamy soil, moderately deep over sandy subsoil, moderately well drained
- M Miscellaneous land types
- Ml Limestone uplands

Ms Colluvial slopes
Mc Creek bottoms
Mm Marshes
Mh Ancient dwelling sites
Mg Cobbly gullies

4. Soil descriptions

4.1 T Terraces

The terraces are found in the southern and eastern parts of the Çumra Area. They are structural and their upper layers have disappeared. There are three kinds in the south (at 1010 m, 1020 m and 1025 m altitude); in most other places there are only two. They are flat (Te) or slightly undulating (Th) and they slope down from the south to the north and from the west to the east. In the west and south-west, at an altitude of about 1040 m, they are dissected by five gullies in north-south direction (Tg), in the west they are only slightly eroded. Near the Village of Okçu the terrace rim is very clear, in the south-east it is vague. Against the rim a beachridge was deposited by the former lake.

In general the terrace soils are loamy and their profiles are clearly developed as a Calciorthid with a pronounced calcic horizon. They are well homogenized.

4.1.1 Te Flat terrace soils

In general the flat terrace soils are deep and loamy. They change in colour with increasing depth from brown and dark-brown over light-pale-brown or reddish-brown to very pale-brown and yellowish-brown with hues from 7.5YR to 10YR. They have a well developed B horizon of at least 50 cm and a calcic horizon overlying a gypsic horizon below 130 cm. The calcic horizon contains powdery pockets and hard concretions, mainly between 40 and 80 cm. The gypsic horizon shows either hard clusters or fine white crystals, locally as veins. Both horizons result from soil formation and gypsum being better soluble in water than calcium carbonate precipitates deeper in the profile. The depths of these horizons largely depend on the amount of downward moving water (during November to January about 25 mm per month), so that in the dry season no real soil formation takes place. The dryness causes a low biological activity in the soil.

The subsoil consists nearly always of soft lime, the origin of which is not yet fully understood (see fig. 7). This subsoil differs from weathered parent rock; presumably it is reworked Neogene chalk in which the profile has developed. It is microscopically very porous, as apparent from soil peels and thin sections.

The flat terrace soils are excellent in porosity, structure and drainage. Supply of water from the River Çarşamba seems possible as they are mostly flat and level to gently sloping. Yet they are only incidentally irrigated.

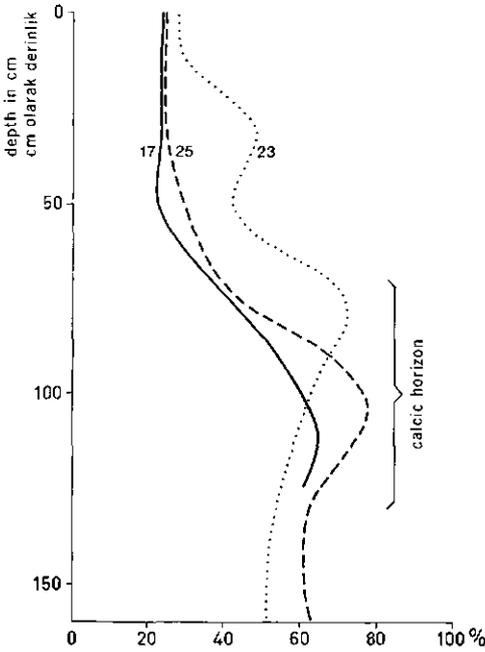


Fig. 7. Carbonate distribution in three terrace profiles.

Şekil 7. Üç teras profilinde karbonat dağılımı.

Their classification is Calciorthids in the 7th Approximation, and Brown Soils in the currently valid USDA-system.

On the flat terraces four soil series have been distinguished: the Beylerce series (Te 1) at an altitude of 1010 m with 4 phases varying in composition, the Okçu series (Te 2) with deep soils at about 1020 m, the Dinlendik series (Te 3) at about 1025 m on flat deep clayey soil (one phase) and the Sevil series (Te 4) at about 1045 m with a deep loamy soil (one phase).

The *Beylerce series* (Te 1), at an altitude of about 1010 m, consists of deep and moderately deep soils with a soft lime subsoil within 120 cm. They perfectly meet the general description of the terrace soils given before. This series occupies part of the terrace formation south of the village of Okçu.

It was mapped in 4 phases, based on differences in texture and depth of the calcareous subsoil, as follows:

deep clayey soil	Te 1.1
moderately deep clayey soil	Te 1.2
moderately deep clayey soil with reddish surface soil	Te 1.3
deep loamy soil	Te 1.4

The *Okçu series* (Te 2), at an altitude of about 1020 m, is found south of the Beylerce soils and in the extreme west of the Çumra Area. Its soils do not differ much from those of the Beylerce series. Invariably they are deep, with a white soft lime subsoil. They differ mainly in their importance for agriculture as related to soil porosity, irrigability and a somewhat better consistency.

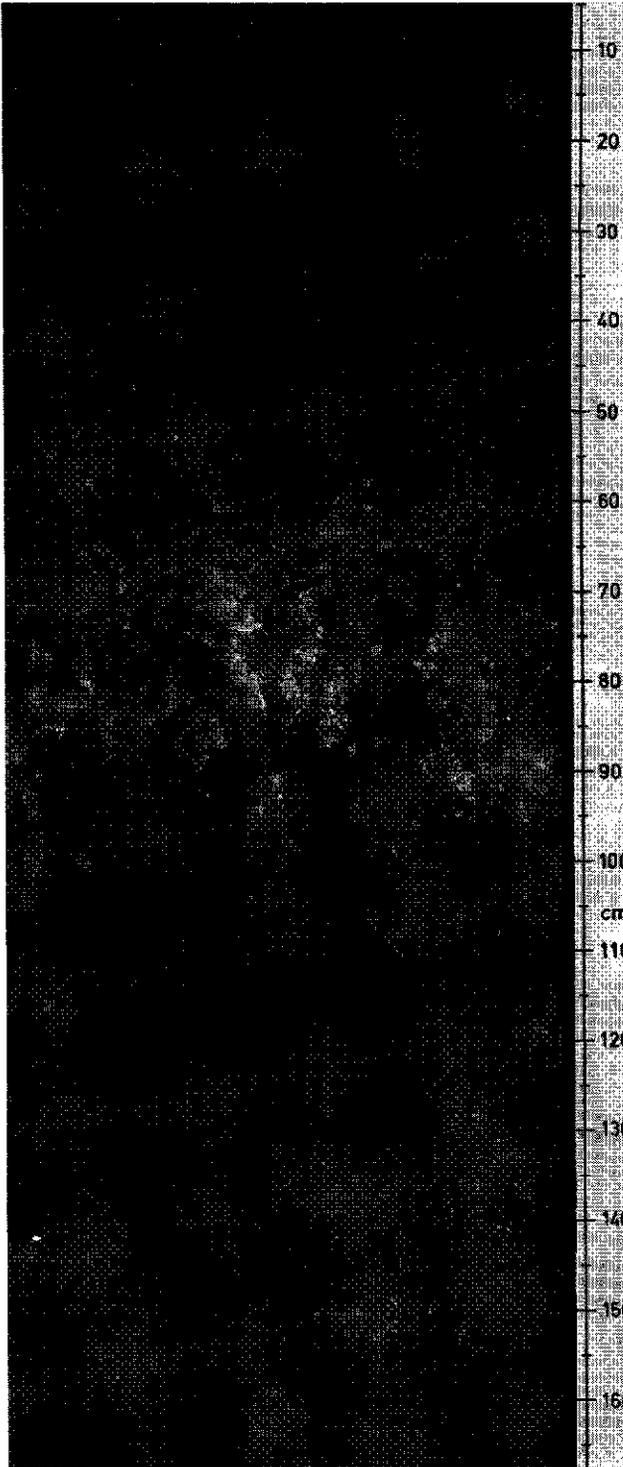


Fig. 8. Profile No 23.
Şekil 8. Profil se no 23.

Te 4: Sevil series, flat terrace soil

Konya. Basin, Çumra Area,
37.2°N¹, 52.4°E, alt. 1015 m,
3-9-1964 (de Meester &
Bannink)

Geology: structural terrace,
parent material: Neogene
limestone

Physiography: terrace

Relief: normal

Slope: gently sloping

Stoniness: class 0

Hydrology: well drained,
watertable deeper than 5 m

Moisture: dry

Salinity: internally saline

Biological activity: few fine
roots, common large and
medium krotovinas all over
the profile

Vegetation: absent

Land-use: wheat in dry farming

Classification 7th Appr.:
1964 Mollic Calciorthid
1967 Mollic Calciorthid

1. Co-ordinates according to
the Topographical Map of
Turkey 1 : 25,000.

A clayey (Te 2.1) and a loamy phase (Te2.2) have been mapped.

The *Dinlendik series* (Te 3) includes clay-loam soils that are more reddish and have a less homogenous and mottled subsoil than the Beylerce and Okçu soils which are more markedly white. Limestone is often found at a depth of over 2 m. Like all terrace soils they contain distinct calcic and gypsic horizons. They occur in the extreme south and west of the Çumra Area at an altitude of about 1025 m.

Only one phase (Te 3.1) was distinguished.

The *Sevil series* (Te 4) consists of soils which do not belong to the true terrace. They have developed on the alluvial fan built up by four gullies crossing the southern terraces in north-south direction and consist of deep-brown loam, locally clay-loam, with layers of fine and coarse gravel and sand. A horizon with pronounced lime mottling and pseudomycelium occurs at depths between 20 and 70 cm. These soils are cultivated, partly under irrigation.

Only one phase (Te 4.1) was distinguished. An example gives Profile No 23 (fig. 8).

Soil description of Profile No 23.

Ap	0- 24 cm	brown to dark-brown (7.5YR 4/4) fine sandy-loam to silt; weak medium-subangular-blocky structure; soft when dry, slightly sticky and slightly plastic when wet; few macropores, many mesopores; lower boundary clear, smooth.
B2ca	24- 44 cm	brown (7.5YR 5/4) fine sandy-loam to silt; moderate medium-subangular-blocky structure; slightly hard when dry, slightly sticky and slightly plastic when wet; many mesopores, macropores common; many fine distinct lime concretions; lower boundary smooth, wavy.
B3ca	44- 60 cm	pink (7.5YR 7/4) silt-loam; strong coarse-subangular-blocky structure; hard when dry, sticky and slightly plastic when wet; many mesopores and macropores; many coarse prominent lime concretions in matrix of soft lime; lower boundary smooth, wavy.
C1ca	60- 88 cm	pink (7.5YR 7/4) silt-loam; strong coarse-subangular-blocky structure; hard when dry, sticky and slightly plastic when wet; many mesopores and macropores; for about 75% consisting of soft lime, for 25% of pink calcareous silt-loam; lower boundary smooth, wavy.
C2ca	88-105 cm	pink (7.5YR 7/4) silt-loam; strong coarse-subangular-blocky structure; hard when dry, sticky and slightly plastic when wet; many mesopores and macropores; consisting of about 30% soft white lime and 70% pink calcareous silt-loam; lower boundary smooth, wavy.
C3ca	105-145 cm	light-brown to yellowish-brown (10YR 5.5/4) silt-loam; strong coarse-subangular-blocky structure; hard when dry, sticky and slightly plastic when wet; many mesopores and macropores; common fine and medium distinct powdery lime pockets and lime concretions; many very fine distinct black manganese concretions; lower boundary smooth, wavy.
C4cacs	145-165 cm	light-brown to yellowish-brown (10YR 5.5/4) silt-loam; strong coarse angular to subangular blocky structure tending towards weak prismatic; hard when dry, sticky and slightly plastic when wet; many mesopores and macropores; few faint medium lime spots; abundant distinct fine gypsum crystals and gypsum veins; common black manganese concretions; few krotovinas with pink (7.5YR 7/4) calcareous silt-loam.

This profile has an ochric epipedon and a cambic and a calcic subsurface horizon.

4.1.2 Th Undulating terrace soils

On the undulating terraces only the *Yavşan series* (Th 1) occurs. In general it consists of shallow or moderately deep soils with angular rock fragments and includes reddish-brown clay-loam soils with a pronounced calcic horizon of white hard lime concretions and soft powdery pockets at 20 to 30 cm. Gypsum has not been recorded. The profile may be truncated by erosion.

This series is subdivided into three phases, based on the depth of the soil:

soil deep, often angular-cobbly	Th 1.1
soil moderately deep, angular-cobbly, over hard limestone	Th 1.2
soil shallow, angular-cobbly, over hard limestone	Th 1.3

4.1.3 Tg Soils of the terrace gullies

The terrace gully soils are grouped as the *Arif series* (Tg 1), subdivided into two phases representing the soils of the slopes (Tg 1.2) and those of the bottom (Tg 1.1) of the gully. The gully bottom soils consist of shallow or moderately deep sandy-loam. In both phases the soil is gravelly and cherty, and no profile has developed. The slopes and the rims of the gullies are mapped as one unit. In the slopes limestone outcrops are common. On the bottoms of the gullies gently sloping areas are found with shallow and moderately deep soils, partly residual on limestone, partly mixed with terrace material; locally they are deep.

As a rule the gully soils are used for ranging.

4.2 A Alluvial plain

In the Çumra Area a number of alluvial deposits occur, which have been grouped into one land type: alluvial plain. Within this land type a number of soil associations have been distinguished on basis of differences in physiographic characteristics and origin of the deposited material.

They are flat or gently sloping, predominantly heavy textured sediments deposited either by river or by a number of small streams originating from the surrounding uplands.

Due to their favourable profile characteristics and hydrological conditions they are all under arable cultivation and are partly irrigated. Fruits, vegetables and various cash crops are widely grown on these soils.

The soils of the alluvial plain have been classified in 4 associations:

- Ar Bajada soils
- Am May fan soils
- Ac Çarşamba fan soils
- Ab Former backswamp soils

4.2.1 Ar Bajada soils

The bajadas, also called fluvial piedmont plains, are found at the borders of the Çumra Area west of the highway connecting Kaşınhanı and Alibey Hüyüğü, and near the Village of Gök Hüyük. This land type forms a transition between the steep slopes of the denuded border hills and the plain; the gradient varies between 1 and 3%.

The soils consist of fluvial deposits of weathered limestone from the cretaceous hills, transported a short distance. They differ from ordinary colluvial deposits in the absence of a clear stratification and in their heavy texture.

Surplus water is drained off in numerous very shallow channels, never more than 2.5 km long, fanning out from a few deeply incised gullies in the steep sides of the hills. Wetting in winter and complete drying up in summer cause a blocky prismatic structure.

In the Çumra Area these soils are reddish, due to their presumed limestone origin. But elsewhere in the Basin dark-brown bajada soils occur, containing a mix of volcanic material.

The soils are generally deep and clayey, often with a brownish surface soil over a yellowish-red solum with hues varying between 5YR and 7.5YR. Usually an Ap horizon is present, with platy structures. They always have a well developed B horizon of 60 cm or more. In many profiles wedge-shaped parallel piped peds and well developed slickensides occur (vertic characteristics). Percolating rain water causes the translocation of clay, resulting in cutans at some 40 cm below the surface. Calcium carbonate was washed out and precipitated at a greater depth so that at present the surface soil has a carbonate content of about 12%, increasing to about 23% in deeper layers. Horizontally, in a toposequence from the hills towards the Basin, the bajada soils show a decrease in carbonate content of the surface soil from 12% to 5%. The carbonate is concentrated again in a calcic horizon, usually at a depth of over 150 cm, consisting of pronounced white spherical powdery pockets, small concretions or pseudomycelium and usually overlain by a horizon with clay illuvation.

All bajada soils have a heavy texture: often over 60% belongs to the fraction $< 2 \mu\text{m}$. The particle size distribution shows a rather constant clay content all over the association: over 75% particles $< 50 \mu\text{m}$ (silt and clay). Generally the clay content slightly increases with depth down to 150 cm, after which it decreases again, presumably because of the presence of a paleosol.

Biological activity is only moderate and only few krotovinas (filled with surface soil material) are found. In several cases the subsurface soil contains wormholes filled with excrements. These 'clay pipes' often contain abundant biogenic aggregates. The relatively low rodent activity is explained by the dryness in summer and the deep watertable. During the dry period the upper 70 cm of the profile is often completely desiccated so that, going from the hills towards the plain, an increase in biological activity may be expected. This was indeed recorded.

According to the currently valid USDA classification system all bajada soils are 'Brown Soils'.

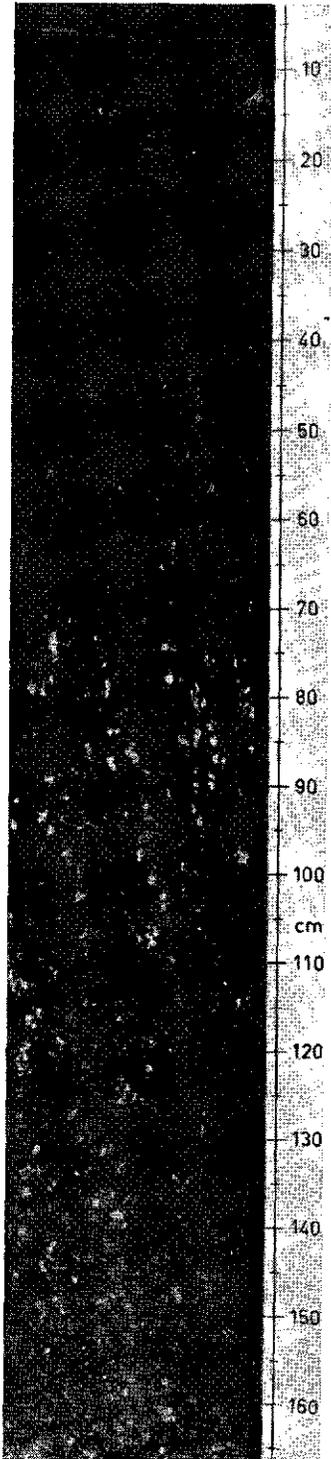


Fig. 9. Profile No 66.

Şekil 9. Profil no 66.

Ar 1.1: Deep clayey soil, Dirabey series, bajada soils

Konya Basin, Çumra Area, 64.5°N, 62.9°E, alt. 1020 m,
4-7-1965 (Slothouwer)

Geology: piedmont plain

parent material: calcareous clay

Physiography: bajada

Relief: normal

Slope: level

Stoniness: class 0

Hydrology: well drained, watertable at appr. 9 m deep

Moisture: dry surface soil over moist subsoil

Salinity: non-saline

Biological activity: moderately rooted down to 140 cm, very
little animal life recorded

Vegetation: absent

Land-use: cereals in dry-farming

Classification 7th Appr.: 1964 Mollic Haplargid

1967 Vertic Haplargid

The association has been divided into two soil series: the Dirabey series and the Çarıklar series.

The *Dirabey series* (Ar 1) consists of soils almost completely meeting the above description. Within it two phases have been mapped, based on the depth of the profile and the occurrence of carbonatic matter in the subsoil: Ar 1.1 with deep soils and Ar 1.2 with moderately deep soils over a carbonatic subsoil. Both occur east of the Terraces in the western part of the Çumra Area. An example of the first gives Profile No 66 (fig. 9).

The *Çarıklar series* (Ar 2) occurs next to the previous series. It consists of soils fanning out over the vast soft lime plain bordering the bajadas in the east at about 1014 m altitude, whereas the Dirabey series occurs between 1019 and 1030 m. The

Soil description of Profile No 66.

- Ap 1 0- 15 cm reddish-brown (5YR 4/4) clay-loam; loose medium and fine subangular-blocky structure; hard when dry, friable when moist, slightly sticky and plastic when wet; common mesopores and macropores; common small limestone gravel; lower boundary abrupt, smooth.
- Ap 2 15- 30 cm reddish-brown (5YR 4/4) clay-loam; strong very thick platy structure; hard when dry, friable when moist, slightly sticky and plastic when wet; few mesopores and macropores; common to frequent fine limestone pieces; lower boundary abrupt, smooth.
- B2t 30- 52 cm dark-reddish-brown (5YR 3.5/4) clay-loam to clay; coarse-subangular-blocky structure; hard when dry, friable when moist, slightly sticky and plastic when wet; few mesopores common macropores; some pseudomycelium, few vertical lime veins; common medium limestone pieces, few fine limestone gravel; lower boundary gradual, smooth.
- IIA1cab 52- 69 cm reddish-brown (5YR 4/4) clay; moderate medium-subangular-blocky structure; hard when dry, friable when moist, slightly sticky and plastic when wet; few mesopores, common macropores; many discontinuous clay coatings; common vertical lime veins and powdery lime pockets with concretions (5 mm) in the middle; lower boundary diffuse, smooth.
- IIB2cab 69- 93 cm yellowish-red (5YR 4.5/6) clay; moderate medium-angular-blocky structure; hard when dry, friable when moist, slightly sticky and plastic when wet; few mesopores and macropores; common to many vertical lime veins and small concretions; few vertical 'clay pipes' (0.75 cm); many continuous clay coatings; lower boundary clear, wavy.
- IIB3cab 93-130 cm reddish-brown to yellowish-red (5YR 4/5) silty-clay; compound weak to moderate fine prismatic and moderate medium-angular-blocky structure, small well-developed slickensides; very hard when dry, friable when moist, slightly sticky and plastic when wet; common small (0.75 cm) 'clay pipes'; many clay coatings on the peds; no mesopores and macropores; very few lime mottles; lower boundary clear, smooth.
- IICcs 130-170 cm reddish-brown to yellowish-red (5YR 4/5) silty-clay; strong to moderate angular-blocky structure, many well developed medium-sized slickensides; very hard when dry; friable when moist, slightly sticky and plastic when wet; no mesopores and macropores; few fine gypsum veins; few krotovinas (6 cm) filled with crumb porous topsoil; weak lime segregation.

This profile possesses an ochric epipedon and a calcic and an argillic subsurface horizon.

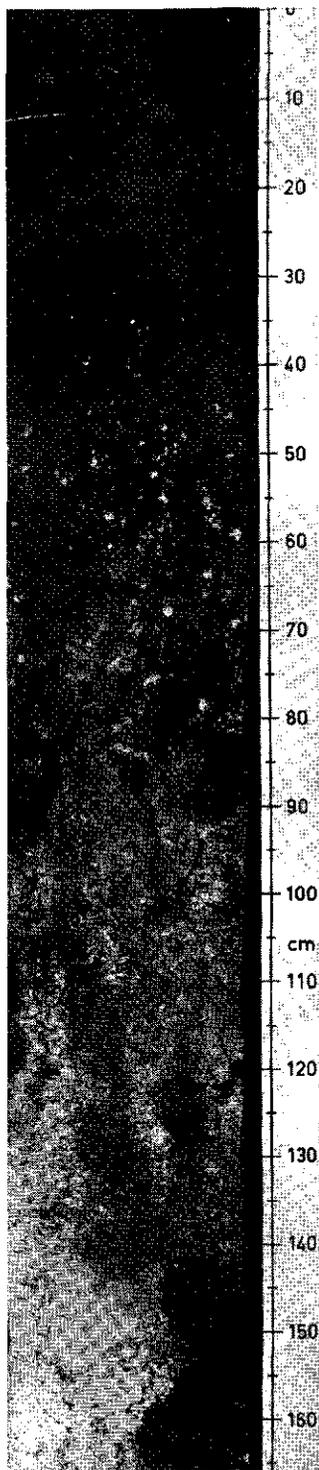


Fig. 10. Profile No 9.

Şekil 10. Profil no 9.

Ar 2.1: Clayey soil, Carıklar series, bajada soils

Konya Basin, Çumra Area, 66.0°N, 64.3°E, alt. 1014 m,
3-7-1965 (Slohouwer)

Geology: bajada

parent material: brown calcareous loam

Physiography: transition from bajada to soft lime plain

Relief: normal

Slope: level

Stoniness: class 0

Hydrology: well drained, watertable between 2 and 4 m

Moisture: dry to about 70 cm, deeper moist

Salinity: non-saline

Biological activity: krotovinas in the upper 105 cm few to
common, deeper few; few roots

Vegetation: absent

Land-use: cereals in dry-farming

Classification 7th Appr.: 1964 Mollic Normargid

1967 Mollic Paleargid

soils of the Çarıklar series are browner and have soft lime in the subsoil.

Only one phase has been mapped (Ar 2.1); an example gives Profile No 9 (fig. 10).

According to the 7th Approximation this soil possesses as diagnostic horizons a calcic and an argillic horizon as well as an ochric epipedon; it has to be classified as a Normargid.

4.2.2 Am May fan soils

The fluvial May fan occupies the southern half of the triangle formed by the terrace soils in the west and south and the railroad Konya-Karaman in the east. The River May debouches into the Basin some 10 km west of the Village of Alibey Hüyüğü. This river, now dry for most of the year, had a torrential regime in the past. As a result its deposits are spread out fanlike, reaching as far as Çumra and somewhat beyond the Village of İçeriçumra. The fan slightly slopes from the apex towards its base; it is almost flat and level; former creek channels and depressions formed by old meanders are frequent and clearly visible on aerial photographs. Locally the subsoil consists of the remains of old terraces.

In general the May fan soils are relatively deep and have a coarse texture near the fan apex, gradually becoming loamy and clayey near its borders. Here and there coarse sandy and gravelly spots occur. The profiles are often stratified, especially where the

Soil description of Profile No 9.

Ap 1	0- 20 cm	brown (7.5YR 4.5/4) silty-clay-loam; moderate to strong very coarse blocky structure; plough layer; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many mesopores, common macropores; lower boundary abrupt and smooth.
Ap 2	20- 39 cm	brown (7.5YR 4/4) silty-clay; compound moderate very thick platy and weak coarse blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many mesopores, common macropores; lower boundary abrupt and smooth.
B2ca	39- 70 cm	brown (7.5YR 4.5/4) clay; moderate to weak medium-subangular-blocky structure; few round elements (1.5 cm); hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common mesopores, many macropores; common prominent powdery lime spots (1 cm); calcareous peds; lower boundary gradual and smooth.
B3ca	70-110 cm	brown to strong brown (7.5YR 5/5) very calcareous silty-clay-loam; weak medium-subangular-blocky structure; few distinct round elements (1 cm); friable to very friable when moist, slightly sticky and very slightly plastic when wet; few mesopores, many macropores; lower boundary gradual, smooth.
IIBcab	110-150 cm	light-brown (7.5YR 6/4) very calcareous clay; friable to very friable when moist, slightly sticky and very slightly plastic when wet; common mesopores, many macropores; one vertical krotovina filled with topsoil; lower boundary gradual, smooth.
IICcab	150-180 cm	light-brownish-gray to very pale-brown (10YR 7/2.5) and white (10YR 8/2) clay; massive; common mesopores, many macropores.

This soil possesses an ochric epipedon and a calcic and an argillic subsurface horizon.

river has a meandering streambed; in general they are only weakly developed. Their colour is as a rule uniformly brown to dark-brown, though often grayish-brown, always within the range of 10YR. Their structure is weak to moderate medium or coarse-subangular-blocky, locally angular-blocky, and even prismatic structures are found in the Ap and C horizons. In the relatively heavy textured lower parts of the fan clay-balls up to 1 cm diameter are present, consisting of small pieces of very compact soil having nearly the same grain size distribution as the matrix as apparent from table 4, but with a moderate fine to medium angular-blocky structure whereas that of the matrix is subangular. Presumably these clay-balls have been translocated from elsewhere. At a depth of 50 to 100 cm secondary lime segregation in the form of pseudomycelium and soft powdery spots are invariably found; they are the result of dissolution and subsequent reprecipitation. The average carbonate content of the soils varies between 6% and 15%.

Especially where the soil is irrigated, high biological activity is witnessed by worm-holes and a completely homogenized surface soil.

Under irrigation the productivity of the May fan soils is high. This also appears from the micromorphological investigations on soil peels and in the thin sections made in the laboratory of undisturbed peds from various depths. Soil structure and porosity seem very favourable for root development.

Near the fan's borders the soil is often irrigated. Gardens supply vegetables and fruits. Near the apex of the fan dry-farming prevails (wheat and other cereals).

Within the association the Alibey series and the İnli series have been distinguished.

The *Alibey series* (Am 1) consists of clayey and loamy (often sandy-loam) soils, mapped in four phases based on differences in texture and subsoil. The first (Am 1.1) has a clayey texture, the others are loamy. Of the latter one is deep (Am 1.2), one is deep with a stratified subsoil (Am 1.3), whereas the last (Am 1.4) is only moderately deep and is underlain by terrace soil. The clayey phase is found in the eastern (lower) part of the May Fan where the finest particles have been sedimented. The deposits in the higher parts may even contain sand and gravel. An example gives Profile No 14 (fig. 11).

The *İnli series* (Am 2) consists of sandy and gravelly soils and has been mapped in three phases: Am 2.1 with a deep sandy profile, Am 2.2 with a deep gravelly-sandy profile, and Am 2.3 consisting of deep coarse sandy and gravelly material.

Table 4. Mechanical analysis of matrix and clay-balls in Profile No 14.

	Percentage of particles / tanelerin yüzdesi			
	< 2 μm	2-16 μm	16-50 μm	> 50 μm
Matrix / matriks	38.2	23.6	15.2	23.0
Clay-balls / kil topu	34.3	35.2	17.7	12.8

Tablo 4. Profil 14 de kil topu ve matriksin tane büyüklüğü.

4.2.3 Ac Çarşamba fan soils

The River Çarşamba enters the Great Konya Basin near the Village of Gökhüyük in the south of the Çumra Area, where it cuts its valley through the terraces. Near Çumra its valley widens into a flat and almost level plain, bordered by a sandridge, where it deposited various soils taken together in the Çarşamba association. In former times the river turned sharply east after leaving the terraces and meandered parallel to the sandridge in the direction of the former Lake Hotamış, so that Çarşamba deposits are found as far as the swampy area bordering it, everywhere between 1002 and 1010 m altitude.

The catchment area of the River Çarşamba is very large (7650 km²). The river must have had a steadier regime than that of the River May because its deposits are less coarse and less stratified. Since 1910 dams have been built for the irrigation of the south-western part of the Great Konya Basin.

The Çarşamba fan soils are in general flat and level, moderately deep to deep, with uniform brown to dark-brown (10YR 4/3) colours. They usually have a uniform, predominantly fine loamy and clayey texture and they may contain up to 60% of particles <2 µm (see table 5); locally sandy subsoils and even completely sandy profiles occur. Loamy deposits are found near the present bed of the river and in parts of its former branches south of the sandridge. Upstream complexes of clayey and loamy deposits forming an intricate pattern of soils could not be separately mapped on the given scale. About 2 km north of Çumra is a small area with brown sandy soils and deep profiles showing alternating layers of coarse and fine sand, often with lime pseudomycelium in the sandy highly calcareous subsoil.

As a rule an A, B and C horizon are present. In the A horizon coarse weak angular-blocky or even prismatic structures are found, just as in the B horizon where they are somewhat more pronounced, however. In several profiles ped surfaces are covered by coatings of illuvial clay.

All these soils contain between 15% and 20% calcium carbonate. The formation of a secondary lime zone is witnessed by few soft lime spots; a real calcic horizon,

Table 5. Mechanical analysis in Profile No 20.

Depth in cm / derinlik, cm	Percentage of particles / tanelerin yüzdesi		
	< 2 µm	20-50 µm	> 50 µm
0- 22	42.7	36.5	18.4
22- 32	47.6	39.3	14.4
32- 83	47.8	39.3	13.5
83-121	38.7	44.6	18.8
121-144	48.0	45.5	8.1
144-165	65.3	34.5	2.8

Tablo 5. Profil 20 de tane büyüklük dağılışı.

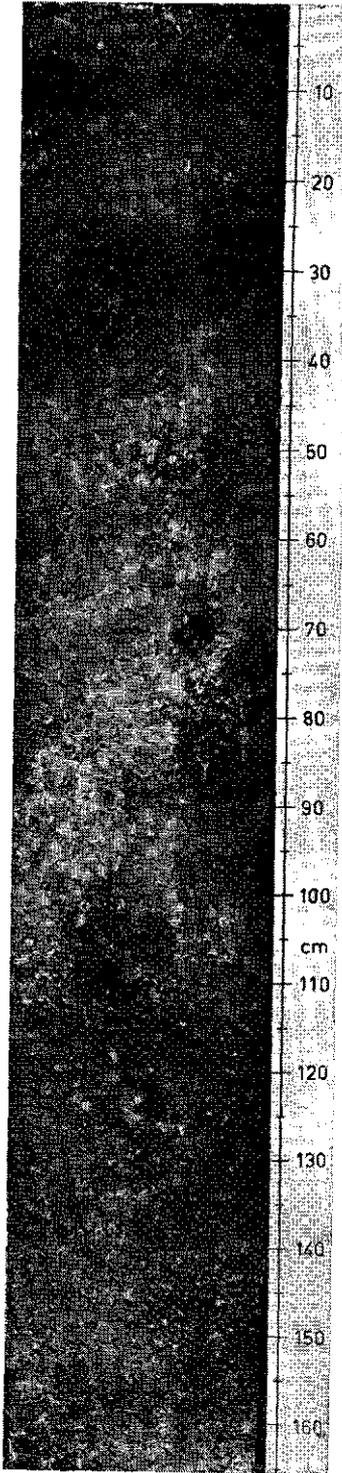


Fig. 11. Profile No 14.
Şekil 11. Profil no 14.

Am: Loamy soil, Alibey series, May fan soils

Konya Basin, Çumra Area, 39.2°N, 36.8°E, alt. 1030 m,
2-9-1964 (de Meester, Bannink & Kadir Gülcan)

Geology: stratified loamy River May deposit

Physiography: May fan

Relief: normal

Slope: level

Stoniness: class 0

Hydrology: watertable at about 3 m

Moisture: dry, subsoil moist

Salinity: internally saline

Biological activity: few roots distributed over the whole profile,
krotovinas common, common open worm-holes

Vegetation: absent

Land-use: wheat in dry-farming

Classification 7th Appr.: 1964 Mollic Camborthid

1967 Ustollic Camborthid

however, is present. Very little gypsum was found, only in prominent white veins.

Krotovinas are common but not frequent; they are always filled with very porous surface material, showing many mesopores and macropores, wormholes and former root channels. The vegetation is deeply rooted.

All Çarşamba soils have a favourable structure and are sufficiently permeable to be suitable for irrigated agriculture. Chemically they differ, depending on their situation. Carbonate contents vary from 10 to 30%.

Many Çarşamba fan soils are irrigated, but dry-farming also occurs. The main crops are wheat, barley, sugar-beet, melon, oats and lucerne. Locally poplars and vegetables are grown. Some saline parts, especially near the Village of Üçhüyüklükler, are grazed by sheep.

Within the Çarşamba association only one series (the *Çumra series*) was distinguished. It was mapped in 12 phases based on difference in texture, depth and drainage as follows:

Clayey soils

deep

- well drained Ac 1.1
- imperfectly drained Ac 1.2
- imperfectly drained, with heavy-clayey surface soil Ac 1.3
- over soft lime Ac 1.4

moderately deep

- over loam Ac 1.6
- over heavy-clay, imperfectly drained Ac 1.7

Loamy soils

- deep Ac 1.8
- deep over coarse subsoil Ac 1.9
- deep over heavy subsoil Ac 1.10

Soil description of Profile No 14.

- Ap 0- 18 cm brown to dark-brown (10YR 4/3) silt-loam; weak fine-subangular-blocky and fine granular structure; hard when dry, slightly sticky when wet; many mesopores and macropores; lower boundary clear, smooth.
- B 2 18- 44 cm brown to dark-brown (10YR 4/3) silt-loam; moderate medium-subangular-blocky structure; hard when dry, slightly sticky and plastic when wet; many mesopores and macropores; common fine faint pseudomycelium; common krotovinas and open wormholes; lower boundary diffuse, smooth.
- B3 44-107 cm do, but with common clay-balls of 1 cm and few of 3-5 cm with a moderate fine to medium angular-blocky structure; friable when moist; many mesopores and macropores between the structural elements, very few pores in the elements; common krotovinas and open wormholes; lower boundary diffuse, smooth.
- IIBb 107-170 cm brown to dark-brown (10YR 4/3) loam; weak medium and fine subangular-blocky structure; friable when moist, slightly sticky and plastic when wet; many mesopores and macropores; common krotovinas and open wormholes; common fine faint pseudomycelium; many clay-balls as described in the text.

This profile possesses an ochric epipedon and a cambic horizon.

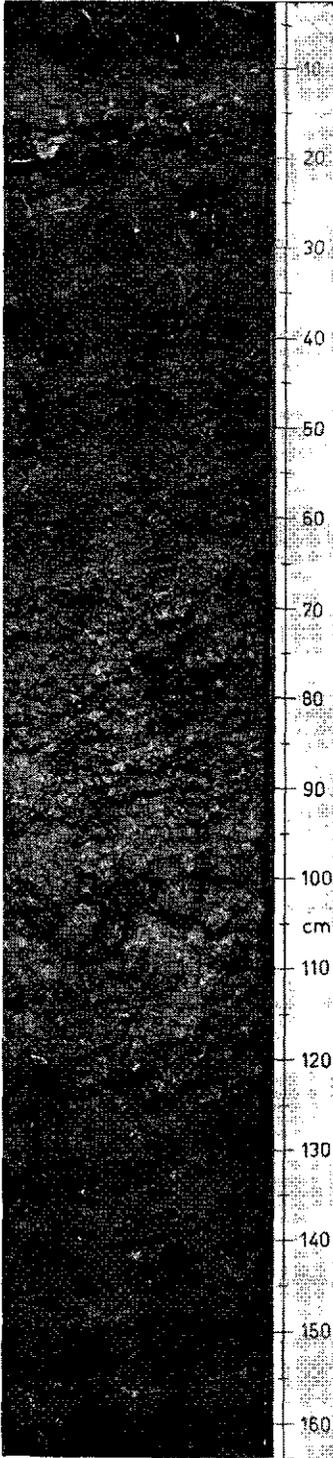


Fig. 12. Profile No 20.

Şekil 12. Profil no 20.

Ac 1: Clay soil, Çumra series, Çarşamba fan soils

Konya Basin, Çumra Area, 37.8°N, 32.7°E, alt. 1012 m,
11-5-1964 (Driessen)

Geology: alluvial clay deposit

Physiography: alluvial plain of River Çarşamba

Relief: normal

Slope: level

Stoniness: class 0

Hydrology: well drained artificially, watertable influenced by
irrigation, average at 170 cm

Moisture: moist

Salinity: non-saline

Biological activity: many roots down to 160 cm, no rodent
activity

Vegetation: grasses

Land-use: parking place for farm machinery

Classification 7th Appr.: 1964 Mollic Calciorthid

1967 Mollic Calciorthid

Complex of deep clayey and loamy soil, imperfectly drained Ac 1.11

Complex of deep sandy soils Ac 1.12

The clayey soils roughly occupy the central, northern and extreme eastern parts (near the Village of Üçhüyükler) of the Çarşamba fan soil association.

An example of a deep well drained clayey soil (Ac 1.1) is Profile No 20 (fig. 12). The dense structure of its upper horizon is probably caused by heavy machinery.

The soil peel of this profile was studied micromorphologically as well as on thin sections from various depths. In the root zone structure and porosity appeared to be very favourable, despite the local platiness in the surface layer.

4.2.4 Ab Former backswamp soils

The former backswamps are comparable with old river basins; they cover large portions of the northern and eastern parts of the Çumra Area. They have the same origin as the Çarşamba fan and the May fan, but they consist of the finest material, sedimented farther away from the (former) rivers, as apparent from the data in table 6. The high clay content results in a high cation exchange capacity if compared with the ordinary Çarşamba and May deposits (table 7).

Soil description of profile No 20.

Ap	0– 22 cm	brown to dark-brown (10YR 4/3) clay; moderate coarse-angular-blocky structure; hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; many mesopores and macropores; few distinct fine to medium white lime pockets; common very fine gravel; lower boundary clear, wavy.
B1ca	22– 32 cm	brown to dark-brown (10YR 4/3) clay; moderate medium prismatic structure; hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; many mesopores and macropores; few distinct fine to medium white lime pockets; some very fine gravel; lower boundary clear, wavy.
B2ca	32– 83 cm	brown to dark-brown (10YR 4/3) clay; weak medium-subangular-blocky structure; hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; many mesopores and macropores; few distinct fine to medium white lime pockets; lower boundary diffuse.
B3ca	83–121 cm	brown to dark-brown (10YR 4/3) loam; weak to moderate medium-angular-blocky structure; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; many mesopores and macropores; few coloured sand grains; common moderate fine to medium lime concretions; lower boundary diffuse; at 117 cm salt efflorescence begins.
C1ca	121–144 cm	brown to dark-brown (10YR 4/3) clay with moderate to strong medium-angular-blocky structure; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; many mesopores and macropores; few prominent fine to medium lime concretions; few coloured sand grains; lower boundary diffuse.
IIBbca	144–163 cm	dark-brown (7.5YR 3.5/3) clay; moderate to strong medium-angular-blocky structure; very hard when dry, firm when moist, slightly sticky and slightly plastic when wet; many mesopores and macropores; common prominent medium white lime concretions and nodules; few coloured sand grains.

This profile has an ochric epipedon and a calcic horizon.

Table 6. Mechanical analysis in Profile No 5.

Depth / derinlik cm	Percentage of particles / tanelerin yüzdesi		
	< 2 μm	2-50 μm	> 50 μm
0- 9	80.6	13.6	5.8
20- 30	79.3	15.9	4.8
40- 50	81.1	13.8	5.1
75- 85	79.2	15.6	5.1
100-110	78.2	17.5	4.3

Tablo 6. Profil 5 in tane büyüklük dağılışı.

Table 7. Cation-exchange capacity in meq/100 g of soil in various profiles.

Depth / derinlik cm	Profile 5	Profile 20	Profile 14
	Çarşamba backswamp deposit / Çarşamba yığılması	Çarşamba deposit / Çarşamba yığılması	May deposit / May yığılması
0- 10	43.3	24.1	19.2
30- 40	44.7	26.1	18.6
70- 80	45.6	27.5	22.0
110-120	46.6	23.8	22.9

Tablo 7. Çeşitli profillerde, 100 g topraksa meq olarak katyon değişim kapasitesi.

The corresponding soils consist of clay-loam to heavy-clay, ranging in colour from dark-yellowish-brown, brown and dark-brown to light-brownish-gray and dark-gray; even almost black soils have been recorded. Generally they are level and almost flat, though locally depressions (old creeks) are present. The major part is poorly drained and consists of smectite type clay showing considerable swelling and shrinking, resulting in up to 7 cm wide and up to 1 m deep cracks in summer which close again after rain in winter; as a result the surface soil is churned and self-mulched. This process leads to high local pressures, causing pressure cutans and slickensides in the subsoil. With the first rains part of the surface clay moves downwards.

The swelling and shrinking also cause the moderate to strong prismatic and angular-blocky structures that develop nearly everywhere in the A horizon; also in the B horizon prismatic structures are common. The surface layer consists of fine angular elements caused by churning.

The carbonate content varies between 15 and 20%. In general they are internally saline; this will be discussed more elaborately in chapter 5. As a rule secondary lime formation is weak; if present it consists of a few faint concretions, some distinct to prominent white fine mottles or sometimes pseudomycelium. The carbonate content seems to be equal throughout the profile.

Locally shell fragments of *Dreissenia* and *Planorbis* occur in the subsoil. This has lead to assume a lacustrine origin, but recent investigations suggest that the molluscs probably lived in local depressions.

Gypsum occurs in many soils and in various forms (spots, crystals, clusters, veins) at depths varying from 50 to 90 cm. Locally rust and manganese mottling can be observed in the subsoil, its intensity depending on the depth of the watertable and its movements, causing alternating reduction and oxydation.

Most of the former backswamp soils are insufficiently drained; the high watertable commonly causes salinization and degradation of the structure.

When these soils are irrigated, the water starts to disappear quickly through the deep cracks and subsequent swelling does not allow any penetration of the water. For this reason the determination of infiltration rates was extremely difficult.

The difference in behaviour when dry and wet also influences land-use so that only supplemental irrigation is applied, and even that is only locally possible. The major part of the soils is under dry-farming; melons and cereals are common, sugar-beet also occurs. A few very saline parts are used for grazing.

In the Çumra Area two types of former backswamp occur:

1. May backswamps, west of the railroad Konya-Karaman. The corresponding soils developed in the River May deposits have a fine texture (up to 80% < 2 µm) and are gray or brownish-gray, moderately deep and locally overlaying lime or calcareous clay.
2. Çarşamba backswamps, covering vast nearly flat areas in the north and east of the Çumra Area. Their soils often consist of swelling clay, brownish or gray.

Within the backswamp association 4 series have been distinguished, two of them divided into different phases:

Karkın series	Ab 1
heavy-clayey soils	
deep, moderately well drained	Ab 1.1
moderately deep over carbonatic subsoil	Ab 1.2
swelling clayey soil, moderately deep, over gypsiferous subsoil, poorly drained	Ab 1.3
clayey soils	
deep, imperfectly drained	Ab 1.4
moderately deep, over light subsoil, moderately drained	Ab 1.5
loamy soils	
moderately deep over clay or calcareous clay	Ab 1.6
moderately deep over clay or calcareous clay, poorly drained	Ab 1.7
Alemdar Series	Ab 2
moderately well to imperfectly drained	Ab 2.1
poorly drained	Ab 2.2
Dedemoğlu Series:	Ab 3
moderately deep, on soft limestone	Ab 3.1
Ovakavaği Series	Ab 4
deep, no vertic character	Ab 4.1

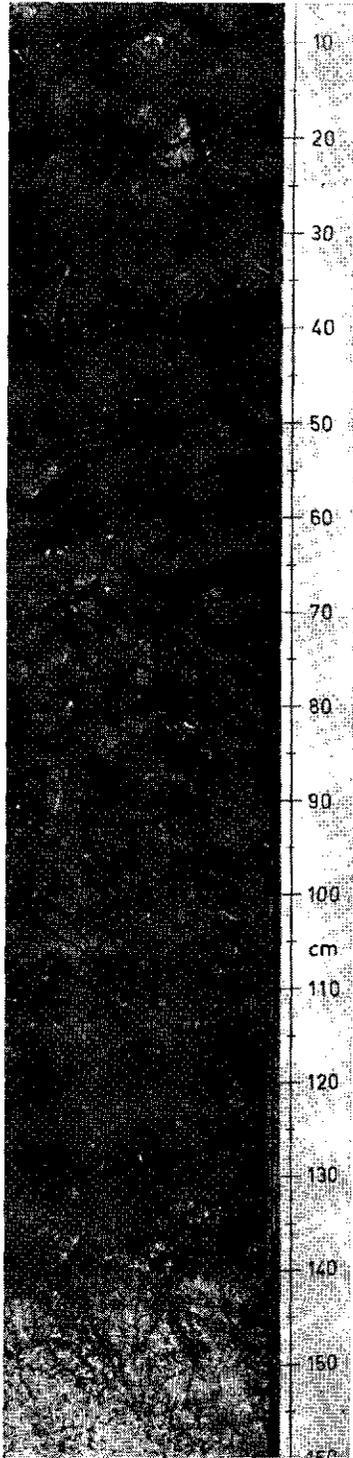


Fig. 13. Profile No 5.

Şekil 13. Profil no 5.

Ab 1.1: Deep, heavy, moderately well drained clay, Karkın series, former backswamp soils

Konya Basin, Çumra Area, 67.0°N, 90.8°E, alt. 1005 m, 9-6-1964 (Driessen)

Geology: alluvial heavy clay plain

Physiography: former backswamp

Relief: normal

Slope: level

Stoniness: class 0

Hydrology: drainage depending on moisture content, in general well drained, watertable deeper than 2 m

Moisture: dry down to 1 m, deeper slightly moist

Salinity: strongly saline, internal solonchak

Biological activity: poor

Vegetation: absent

Land-use: dry-farming, often with supplementary irrigation

Classification 7th Appr.: 1964 Entic Grumustert

1967 Aquic Entic Chromoxerert

The *Karkın series* (Ab 1) includes deep and heavy-clayey soils with a clay content of 60–70%, sedimented by the River Çarşamba. Generally they are grayish, but locally black colours prevail, presumably caused by dispersed organic matter, though the organic carbon content remains below 0.45%.

This series has a subsoil of white marl, ranging in depth between 1.10 and 4 m. Depressions with poorly drained gypsiferous or rusty profiles are found, particularly near Lake Hotamiş in the eastern part of the area.

The *Karkın series* has been subdivided into 7 soil phases based on depth, subsoil and drainage conditions. The most characteristic phase is that consisting of deep moderately drained heavy-clay (phase Ab 1.1); a representative example gives Profile No 5 (fig. 13).

Soil description of profile No 5.

- Ap 1 0– 9 cm light-brownish-gray to grayish-brown (10YR 4.5/2) clay-loam to clay; moderate fine-angular-blocky structure; very hard when dry, soft to slightly hard when moist, slightly sticky and plastic when wet; few prominent fine white lime concretions; lower boundary clear, wavy. This horizon forms a self-mulching surface layer.
- Ap 2 9– 37 cm light-brownish-gray to grayish-brown (10YR 4.5/2) clay-loam to clay; moderate coarse-angular-blocky structure; very hard when dry, slightly hard when moist, slightly sticky and plastic when wet; few distinct fine white lime concretions; common mesopores, few macropores; lower boundary diffuse, wavy.
- B 1 37– 62 cm grayish-brown (10YR 5/2) clay; strong coarse-angular-blocky structure; very hard when dry, hard when moist, slightly sticky and plastic when wet; few faint, fine, lime concretions; common mesopores, few macropores; lower boundary gradual, wavy.
- B 2 62– 93 cm grayish-brown (2.5Y 4.5/2) clay; strong coarse-angular-blocky structure; parallel piped elements, pronounced slickensides; very hard when dry, hard when moist, slightly sticky and very plastic when wet; few faint, fine, lime concretions and soft spots; few mesopores and macropores; lower boundary gradual, wavy.
- B 3 93–118 cm grayish-brown (2.5Y 4.5/2) clay; moderate medium-angular-blocky structure; very hard when dry, slightly hard when moist, slightly sticky and plastic when wet; parallel piped structure elements, intersecting slickensides; few fine gravel in lower part of horizon; common faint, fine, rust mottles; few mesopores and macropores; lower boundary gradual, wavy.
- C 1 118–135 cm light-gray (2.5Y 7/2) calcareous loam; massive and slightly cemented; very hard when dry, slightly hard when moist, slightly sticky and plastic when wet; few fine shell fragments; common gravel, 1–2 cm; lower boundary clear, wavy.
- C 1/IIC2 135–151 cm light-gray to light-brown-gray (2.5Y 6.5/2) calcareous loam; massive and slightly cemented; very hard when dry, slightly hard when moist, slightly sticky and plastic when wet; few fine shell fragments; lower boundary diffuse, smooth. This horizon is a transition to the next one.
- IIC2 151–200 cm light-brownish-gray (2.5Y 6/2) loam; massive; slightly sticky and slightly plastic when wet; few macropores.

This profile has an ochric epipedon and vertic features.

The *Alemdar series* (Ab 2) consists of better drained Çarşamba material. These vertisols lie roughly in the triangle between the villages of Dedemoğlu, Alemdar and Küçük Köy and are characterized by a brownish colour, ranging from dark-yellowish-brown to brown and dark-brown, and by the occurrence of rust or manganese mottling in the subsoil. Locally a B2t horizon with clay skins was recorded.

Two soil phases, based on different drainage conditions have been mapped. Both are deep heavy-clayey soils. Soil phase Ab 2.2, however, has a silt-loam surface soil.

For the *Dedemoğlu series* (Ab 3) only one phase was mapped, east and north-west of the Village of Dedemoğlu, north of Fethiye and south of the Konya-Karaman railroad. Its soils are moderately deep with a soft lime subsoil. Partially they are considered transitional between the Karkın or Alemdar heavy-clayey soils and the soft lime association. The eastern part, next to the May fan, is probably developed on River May deposits. Only the well drained parts of the Dedemoğlu series are cultivated.

Also for the *Ovakavağı series* (Ab 4) only one phase was mapped, east of Ovakavağı in the north-eastern part of the Çumra Area. This series also occurs about 2 km west of the Village of Türkmen Karahüyük. The soils are of the same colour as the Karkın heavy clays, but they lack the vertic characteristics with regard to phenomena such as slickensides and parallel piped elements.

In the eastern and northern parts of the Çumra Area, clay dunes on backswamps (Ab 1.1) occur. They are aeolian and consist of fine very saline aggregates about 2 mm in diameter of heavy-clay behaving like sandgrains (pseudosand).

Directly south-west of Türkmen Karahüyük a small area is covered by irrigation deposits. Near the main irrigation canal this cover has a thickness of about 70 cm; it slowly fans out to a width of about 1 km. Such a phenomenon may be observed at several places on Çarşamba fan soils, backswamps and irrigated gardens, though nowhere as evident as near Türkmen Karahüyük. Profile No 43 shows a representative example from this area.

Profile No 43 (no photograph available)

Ab 4.1: Deep, heavy, moderately well drained clay, Ovakavagi series, former backswamp soils
Konya Basin, Çumra Area, 62.6°N, 1.8°E, alt. 1000 m, 2-9-1966 (Driessen & van Vuure)

Geology: alluvial clay deposit

Physiography: backswamp covered by River Çarşamba irrigation sediments

Relief: normal

Slope: level

Stoniness: class 0

Hydrology: moderately well drained

Moisture: moist throughout the profile

Salinity: non-saline

Biological activity: few roots and worm-holes, no rodent activity

Vegetation: absent

Land-use: melons under irrigation

Classification 7th Appr.: 1964 Aeric Cumulic Normaquet
1967 Aeric Fluventic Haplaquet

Soil description of Profile No 43.

- Ap 0– 17 cm brown to dark-brown (10YR 4/3) clay; weak medium to fine subangular-blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few mesopores and macropores; few roots of different sizes; lower boundary abrupt, smooth.
- C 1 17– 33 cm brown to dark-brown (10YR 4/3) stratified sandy-loam; massive and structureless; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many mesopores and common macropores; common fine and medium roots; lower boundary abrupt, smooth.
- C 2 33– 45 cm dark-brown (10YR 3.5/3) clay; strong medium to coarse prismatic structure; very hard when dry, friable when moist, sticky and slightly plastic when wet; few mesopores and macropores; common fine and medium roots; few shell fragments, few prominent fine white gypsum veins; common, distinct, dark, reddish-brown (5YR 4/3) large rust mottles; some fine sand originating from C 1 horizon; lower boundary abrupt, smooth.
- C 3 45– 52 cm brown to dark-brown (10YR 4/3) sandy-loam, massive, structureless; consistency see C 1; common mesopores and macropores; few old root channels; common medium and fine roots; few shell fragments; few fine, white, distinct gypsum veins; common distinct rust mottles along old root channels; horizon stratified with sandy layers; lower boundary abrupt, smooth.
- C 4 52– 67 cm dark-brown (10YR 3.5/3) sandy-loam; massive, structureless; consistency see C 2; few fine roots; few distinct very fine gypsum veins; common to many large dark-reddish-brown (5YR 4/3) distinct rust mottling; lower boundary abrupt, smooth.
- IIA 67– 77 cm dark-gray (10YR 4/1) clay; moderate to strong medium-prismatic structure; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few mesopores and common macropores; common fine and medium roots; few distinct fine rust mottles along former root channels; few distinct fine and medium white lime concretions and mottles; few cracks, less than 1 mm in diameter; few prominent fine white gypsum veins; lower boundary clear, smooth.
- IIC' 77–150 cm dark-gray (10YR 4/1) clay; weak medium-subangular-blocky structure; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few big and medium roots; few prominent fine white lime concretions; few fine shell fragments; few faint rust mottles.

This profile has an ochric epipedon over a cambic horizon.

4.3 L Lacustrine plain

Vast parts of the Çumra Area belong to the land type of the lacustrine plain. They are flat or gently sloping and of a fairly homogeneous composition. Except for the beachridges and sandplains they consist of 50 to 90% calcium and magnesium carbonates.

Depending on the carbonate content a distinction has been made between soft lime soils (> 80% carbonates) and marl soils (50–80%). The soft limes are not very well suited for arable cultivation because of their high salt content and their unfavourable hydrological conditions, which hamper plant growth severely. Marl soils, locally having a clayey surface soil and a lower watertable (> 1 m) than the soft lime soils, have better agricultural properties. The lacustrine sandy soils are in general used for ranging and extensive dry-farming. Locally irrigated fruitgardens are present.

The soils of the lacustrine plains have been divided into 4 associations:

- Lc Soft lime soils
- Lm Marl soils
- Lr Ridge soils
- Lp Sandplain soils

4.3.1 Lc Soft lime soils

The slightly undulating soft lime plains occupy the north-west and south-east of the Çumra Area.

They consist of almost pure (up to 95%) carbonates of calcium and magnesium and are unconsolidated Neogene carbonate deposits, locally reworked and mixed with recent precipitates. In some places, especially west of the main road from Kaşınhanı to İçeriçumra, they cover hard Neogene limestone, presumably the outcrops of a structural terrace flattened by abrasion and causing some irregularities in the otherwise flat terrain. In the northern part of the Çumra Area depressions are dotted about with a high watertable, sometimes even with surface water or pools. In higher parts the watertable is about 150 cm below the surface as can be seen in the numerous wells made for irrigation of the nearby sandridge.

The soft lime soils, developed on the soft lime itself are white, level and usually very shallow; locally they contain some loam or clay.

Their profiles generally have a thin A horizon of very calcareous loam or clay ranging in colour from grayish-brown to dark-brown. Locally they are covered by a shallow backswamp layer fanning out over the soft lime plain. Where the surface soil is clayey, prismatic structures develop as a result of alternative drying and wetting; where the surface is loamy, angular and subangular blocky or sometimes platy structures occur. Although in some places a B horizon is present, the A horizon usually rests directly on the unchanged massive, structureless limestone parent material, which may be concreted. Some profiles have sandy or silty material in the massive and structureless subsoil, ranging from weak subangular-blocky to strong coarse prismatic, depending on the texture of the surface soil.

Gypsum is rarely detectable. A calcic horizon has sometimes been detected by chemical analysis.

The soils are covered with poor grasses or form poor arable land. Their poverty is due partly to bad chemical conditions, partly to waterlogging.

Within the soft lime association 2 series have been distinguished; the Ürünlü series and the Kaşınhanı series, each with various phases:

- | | |
|--|--------|
| Ürünlü series, imperfectly drained | Lc 1 |
| moderately deep loamy surface soil | Lc 1.1 |
| shallow loamy surface soil | |
| shallow loamy surface soil | Lc 1.2 |
| shallow loamy surface soil, containing concretions | Lc 1.3 |
| shallow clayey surface soil | Lc 1.4 |

Kaşınhanı series, soft lime over limestone, moderately well drained	Lc 2
moderately deep loamy surface soil	Lc 2.1
shallow loamy surface soil	Lc 2.2
very shallow loamy surface soil	Lc 2.3

The *Ürünlü series* (Lc 1) occupies the north-western part of the Çumra Area, small areas near Ürünlü and south of the sandridge between Fethiye and Kaşınhanı, and a vast area near the Village of Taşağil in the south-eastern part of the Çumra Area, at altitudes between 1002 and 1005 m. They are very flat and level.

Their soils consist of light-gray, gray or white soft lime with a grayish-brown or light-brownish-gray loamy or clayey surface layer. Locally limestone is present, almost always below 150 cm. In nearly all profiles the surface layer contains distinct fine white lime concretions; the subsoil rarely contains shells or shell fragments; gypsum segregation is rare; below 100 cm rust mottles are common. Phase Lc 1.3 frequently contained clay durinodes, presumably formed under wet conditions.

A representative example of phase Lc1.1 is Profile No 26 (fig. 14).

The *Kaşınhanı series* (Lc 2) has been mapped in the north-western part of the Çumra Area at either side of the sandridge between Kaşınhanı and Fethiye and near the Village of Ürünlü, in both cases between 1005 and 1009 m. Its soils are flat and level. In the north-west the watertable is between 100 and 150 cm, near Ürünlü usually 3–4 m. Near Ürünlü the subsurface soil is completely dry in summer, whereas near the Village of Kaşınhanı only the upper 60 to 70 cm dry out.

The soils of the Kaşınhanı series are in general covered by grasses, their quality depending on depth, texture and moistness of the surface soil. They are used for grazing. South of the sandridge, soils between Kaşınhanı and Fethiye are irrigated. The water is pumped from the subsoil; its quality is fair and it is used to irrigate crops such as sugar-beet and melons.

These soils are generally classified as Haplustolls or Haploxerolls because of their mollic epipedon. But Aridisols are found as well, just as in the previously described Ürünlü Series. According to the USDA system these soils belong to the Calcisols.

Within the Kaşınhanı series 3 soil phases have been distinguished according to the depth of the clayey or loamy surface soil, here the most important factor for agriculture.

The carbonate content may be as high as 80 or 90%. But the composition varies, as shown by figure 15, which gives the amount and composition of the soft lime in 2 profiles, one near the Village of Ürünlü, the other 8 km north of Kaşınhanı, just outside the Çumra Area (Pireli Kas). The high Mg content of the latter may be ascribed to the mountains south-east of Konya, where magnesite is mined. The high content of bivalent cations induces deficiency symptoms in the crops; especially those for phosphate and potassium are common.

In the field all soft lime soils have a heavy-clayey texture, but laboratory investigations revealed that many of the clay particles are of lime, particularly those < 2 μm (table 8).

Near Ürünlü CaCO_3 cements the clay particles together, so that after its removal the carbonate fraction < 2 μm increases. The profile denoted as Pireli Kas (and

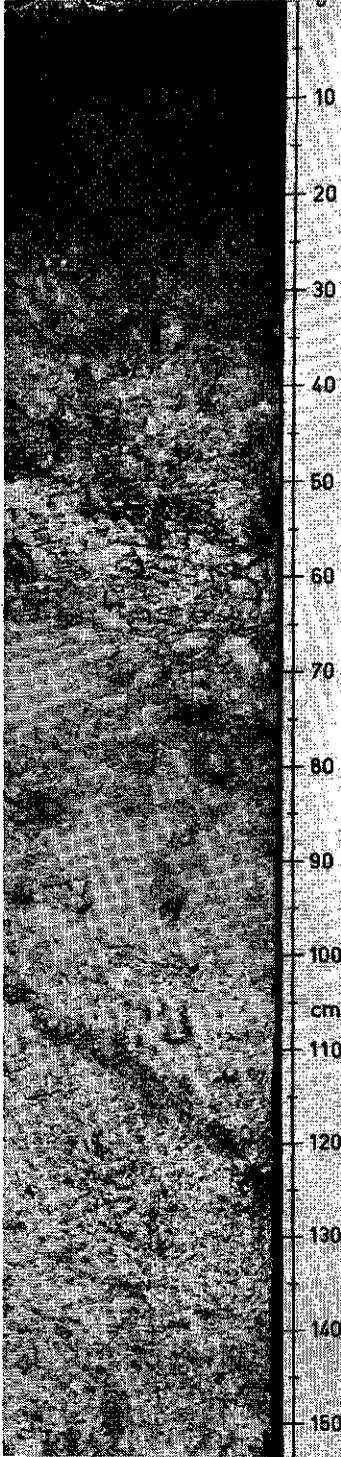


Fig. 14. Profile No 26.

Şekil 14. Profil no 26.

Lc 1.1: Moderately deep loamy soil, Ürünlü series, soft lime soils

Konya Basin, Çumra Area, 37.2°N, 38.7°E, alt. 1005 m, 23-8-1964 (van Blom)

Geology: Neogene and recent soft lime

Physiography: soft lime plain

Relief: flat

Slope: level

Stoniness: class 0

Hydrology: imperfectly drained, watertable 160 cm

Moisture: dry

Salinity: saline

Biological activity: Abundant roots in upper 10 cm, few roots as far as 1 m

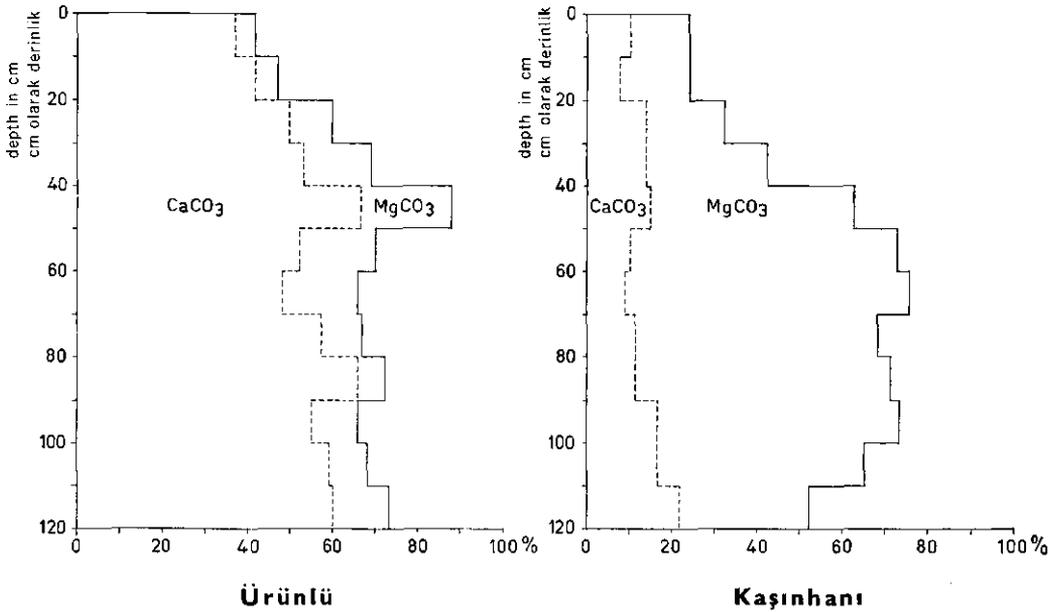
Vegetation: short grasses

Land-use: pasture

Classification 7th Appr.: 1964 Aquic Haplorthent

1967 Aquic Xerorthent

Fig. 15. Composition of the carbonates near Ürünlu and Kaşınhanı.



Şekil 15. Ürünlü ve Kaşınhanı yakınlarında karbonatların bileşimi.

Soil description of Profile No 26.

- A 11 0- 6 cm grayish-brown (10YR 4.5/3) loam; weak thin platy structure; soft when dry, friable when moist, sticky and slightly plastic when wet; few mesopores and macropores; lower boundary abrupt, smooth.
 - A 12 6- 24 cm grayish-brown (10YR 4.5/3) loam; weak coarse-subangular-blocky structure; slightly hard when dry, friable when moist, sticky and slightly plastic when wet; few mesopores and macropores; lower boundary clear, wavy.
 - AC 24- 46 cm very pale-brown (10YR 7/2) clay-loam; weak medium-angular-blocky structure; slightly hard when dry, very friable when moist, very sticky and slightly plastic when wet; few faint white concretions of lime; few mesopores and macropores; lower boundary abrupt, wavy.
 - C 1 46- 97 cm white (10YR 8/2) clay-loam (soft lime); moderate medium-angular-blocky structure; locally platy structures; hard when dry, very friable when moist, very sticky and slightly plastic when wet; few lime concretions; few mesopores and macropores; lower boundary clear, wavy.
 - C 2 97-105 cm white (5Y 8/1) clay-loam (soft lime); massive and structureless; very hard when dry, very friable when moist, very sticky and slightly plastic when wet; common medium faint iron mottles, common medium lime concretions surrounded by rust mottling; lower boundary clear, wavy.
 - C 3 105-128 cm do; few coarse lime concretions surrounded by rust mottling; lower boundary clear, wavy.
 - C 4 128-140 cm do; few coarse lime concretions surrounded by rust mottling.
- This profile possesses an ochric epipedon only.

Table 8. Mechanical analysis before and after removal of carbonates

	Depth in cm	Particle size (weight %)		
		< 2 μm	2-50 μm	> 50 μm
Ürünli (26)				
with carbonates / kireçli	60-70	23.4	56.1	20.5
carbonates removed / kireci çıkarılmış	60-70	30.7	22.7	26.6
Pireli Kas				
with carbonates / kireçli	70-80	60.0	24.1	7.9
carbonates removed / kireci çıkarılmış	70-80	30.3	41.2	28.5
		< 2 μm	2-50 μm	> 50 μm
	Derinlik, cm	Tane büyüklüğü		

Tablo 8. İki profilde kirecin çıkarılmasından önce ve sonra topraklarda tane büyüklük dağılışı.

presumably large parts of the lime plain near Kaşınhanı) shows a decrease in clay content after the removal of the carbonates. This is due to peptization (under wet circumstances) of the lime caused by the high percentage of Na^+ at the soil complex.

Severe salinity and alkalinity have repeatedly been recorded for the soft lime soils.

4.3.2 Lm Marl soils

The marl soil association occupies the north-eastern corner of the Çumra Area and small patches near the villages of Dedemoğlu and Taşağıl.

Its soils are part of the former bottom of the ancient lake in which calcium and magnesium carbonates were precipitated under the influence of the aquatic vegetation. But as the water was turbulent, some silt is also deposited. In this respect they differ from the soft limes because the resulting soils have a considerably lower carbonate content: about 60%, whereas the soft lime soils may exceed 80%. Locally the marl soils are covered by Çarşamba deposits. They are deep, flat and level except for a number of gullies and a sandridge, and they range from carbonatic silt to clay; locally deposits of stratified fine sand occur. They range from dark-grayish-brown to white. In general they feature an A horizon with weak platy structure. The B horizon has a weak to moderate fine and medium subangular-blocky structure, prismatic and angular-blocky elements being recorded as well. The lacustrine origin also appears from the local occurrence of numerous shell fragments (mainly *Dreissenia*) in the subsoil.

Often there is a calcic horizon with white lime pockets, mottles or concretions. There are many rust mottles, indicating a fluctuation in the watertable, especially along the tracks of old roots penetrating deeper than 50 cm.

The marl soils are not very permeable though investigations on soil peels and thin sections show a rather good porosity. The watertable varies between 1.5 and 4 m; the

soils vary from imperfectly drained to well drained.

Biological activity in the marl soils is of major importance for soil formation, since few to many krotovinas down to about 120 cm occur and roots penetrate to 80 cm.

Most soils of this association are under dry-farming (mainly wheat); locally at salt-free spots supplementary irrigation is practised during growth of the crops. In saline areas only ranging of cattle is possible.

As mentioned above, the marl soils consist of about 60% carbonates. Analysis shows a relative increase of the clay fraction after its removal (table 9).

Many of the marl soils have a texture with, at most, a few percentages $> 50 \mu\text{m}$.

The marl soils are often internally saline.

Within the marl soil association 5 soil series have been distinguished, two of them subdivided:

Demirkent series: deep carbonatic silt-loam and silty-clay-loam	Lm 1
deep carbonatic loamy soil	Lm 1.1
deep carbonatic loamy soil with stratified subsoil	Lm 1.2
Serpil series: shallow clayey surface soil on moderately deep carbonatic soil,	Lm 2
poorly drained	Lm 2.1
Pınarbaşı series: carbonatic clay soils	Lm 3
deep imperfectly drained carbonatic clayey soil	Lm 3.1
moderately drained, angular-cobbly carbonatic clayey soil	Lm 3.2
Süleyman Hacı series	Lm 4
deep gypsiferous carbonatic clayey soil	Lm 4.1
Ahmet Hoca series	Lm 5
deep silty-clay	Lm 5.1

The *Demirkent series* (Lm 1) occupies the north-eastern corner of the Çumra Area between the villages of Demirkent and Türkmen Karahüyük. It includes soils of deep carbonatic silt-loam and silty-clay-loam, with a carbonate content of about 40%; they are grayish-brown with a white subsoil. The watertable varies between 1.50 and 4 m.

Table 9. The effect of removal of carbonates on the mechanical analysis of Profile No 3.

Depth in cm / cm olarak derinlik	Fractions					
	$< 2 \mu\text{m}$		$2-50 \mu\text{m}$		$> 50 \mu\text{m}$	
	+ carb. / kireç	- carb. / kireç	+ carb. / kireç	- carb. / kireç	+ carb. / kireç	- carb. / kireç
5- 15	17.8	34.7	50.4	47.7	22.8	16.6
125-130	27.2	30.7	43.9	44.6	28.9	24.7

Tablo 9. Profil 3'de kireç giderilmesinin bazı fraksiyonlar üzerine olan etkisi.

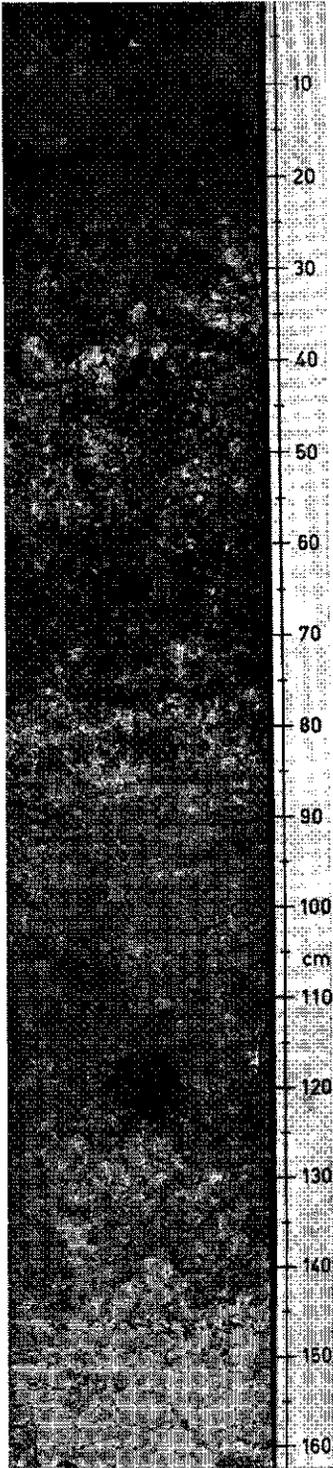


Fig. 16. Profile No 55.

Şkil 16. Profil no 55.

Lm 1.2: Stratified loamy soil, Demirkent series, marl soils

Konya Basin, Çumra Area, 72.5°N, 02.9°E, alt. 1000 m,
24-9-1964 (de Meester & van Blom)

Geology: lacustrine carbonatic silt-loam

Physiography: marl plain

Relief: normal

Slope: level

Stoniness: class 0

Hydrology: well drained, watertable at about 4 m

Moisture: upper 100 cm dry, subsoil moist

Salinity: internally saline

Biological activity: roots common in upper 50 cm, few
krotovinas down to 150 cm

Vegetation: absent

Land-use: wheat in dry-farming, presently fallow

Classification 7th Appr.: 1964 Aquic Calciorthid
1967 Aquic Calciorthid

The soils are mainly under dry-farming except immediately around Demirkent where wheat, sugar-beet and vegetables are grown on fields irrigated by pumping.

This series has been subdivided into two phases, based on the absence (Lm 1.1) or presence (Lm 1.2) of local clayey layers in the subsoil. Profile No 55 (fig. 16) gives an example with such layers.

The *Serpil series* (Lm 2) occupies a small area about 5 km north-west of the Village of Dedemoğlu. It includes deep carbonatic clayey soils, light-brownish to white with a light-gray to grayish-brown clayey surface layer of backswamp origin 30 to 60 cm thick. The watertable is about 120 cm.

These soils are imperfectly drained and suffer from severe salinization, especially in depressions, so that their vegetation consists of poor grasses and halophytic plants suitable only for ranging sheep.

This series was mapped in one phase only (Lm 2.1).

The *Pınarbaşı series* (Lm 3) occurs only in the south-eastern part of the Çumra Area. Its soils consist of light-brownish-gray and light-grayish deep carbonatic loam and clay, locally covered by a brown loamy layer, especially near the limestone hill in the very south-east of the area.

Small dunes consisting of marl have been mapped near the border of Lake Hotamış; partly these soils are angular-cobbly.

Soil description of Profile No 55.

- | | | |
|----------|------------|---|
| Ap | 0- 19 cm | grayish-brown (2.5Y 4.5/2) silt-loam; moderate fine platy structure; slightly hard when dry, sticky and plastic when wet; common mesopores and macropores; lower boundary clear, smooth. |
| B 2.1 | 19- 56 cm | dark-grayish-brown (2.5Y 4/2) calcareous silt-loam; moderate medium compound prismatic structure; slightly hard when dry, sticky and plastic when wet; common mesopores and macropores; common white lime spots; lower boundary gradual, smooth. |
| B 2.2 | 56- 75 cm | brown (10YR 5/3) calcareous silt-loam; moderate medium compound prismatic structure; slightly hard when dry, sticky and plastic when wet; common medium distinct rust mottles (10YR 6/6); lower boundary abrupt, smooth. |
| B 3cs | 75- 84 cm | grayish-brown (2.5Y 5/2) calcareous silt; weak subangular-blocky structure; slightly hard when dry, slightly sticky and plastic when wet; common mesopores and macropores; abundant white gypsum veins; common medium distinct rust mottles; lower boundary gradual, wavy. |
| C 1cs | 84-104 cm | do, but less gypsum veins. |
| C 2cs | 104-120 cm | grayish-brown to light-brownish gray (2.5Y 5.5/2) silt-loam, alternating with fine layers of very fine sand; weak medium-subangular-blocky structure; few krotovinas; common weak white gypsum veins, common gypsum crystals; few medium distinct rust mottles; lower boundary gradual, smooth. |
| C 3cs | 120-140 cm | grayish-brown to light-brownish-gray (2.5Y 5.5/2) silty-clay-loam; weak medium-subangular-blocky structure; many medium gypsum crystal clusters; lower boundary gradual, wavy. |
| (II)C4cs | 140-162 cm | pale-brown (10YR 6/3) silty-clay-loam; strong medium-angular-blocky structure; friable when moist, sticky and plastic when wet; few mesopores and macropores; many gypsum clusters, few fine manganese concretions. |

This profile has an ochric epipedon and a cambic, gypsic and calcic horizon.

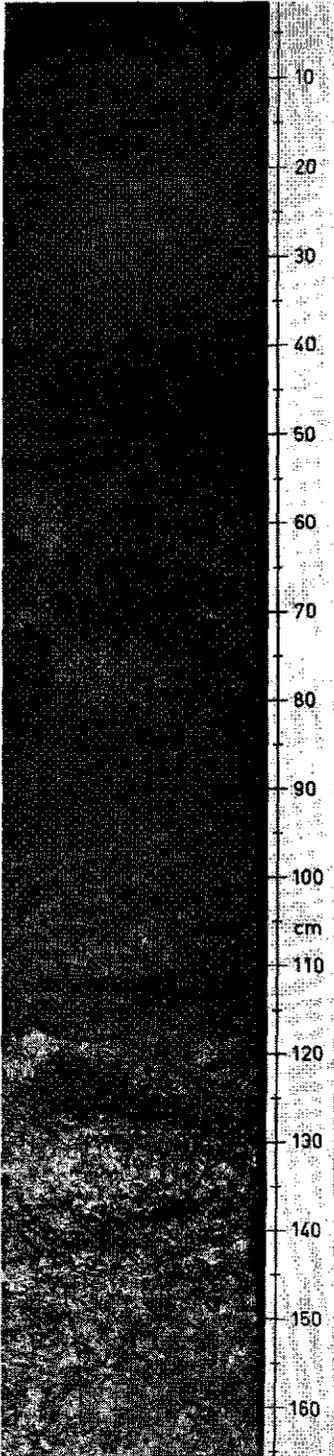


Fig. 17. Profile No 31.
 Şekil 17. Profil no 31.

Lm 5.1: Silty clay soil, Ahmet Hoca series, marl soils

Konya Basin, Çumra Area, 54.4°N, 94.4°E, alt. 1005 m,
 5-8-1965 (Peters)

Geology: recent lacustrine carbonatic clay

Physiography: recently dried swamp

Relief: normal

Slope: level

Stoniness: class 0

Hydrology: moderately well drained, watertable 150 cm

Moisture: moist

Salinity: saline

Biological activity: surface soil well rooted, pronounced
 krotovina activity

Vegetation: grasses

Land-use: pasture

Classification 7th Appr.: 1964 Aquic Calciorthid
 1967 Aquic Calciorthid

The soils are used for cattle ranging only.

The series has been mapped in 2 phases (Lm 3.1 and Lm 3.2), the latter more stony.

The *Süleyman Hacı series* (Lm 4) occurs at an altitude of about 1000 m. Its soils show signs of their recent inundation. They consist of deep carbonatic silt or silty-clay. A light-brownish-gray carbonatic silt-loam surface soil often prevails, followed by 20–60 cm usually very dark-grayish-brown organic soil with a silty texture. This organic layer is considered to represent the former swamp surface; the overlying carbonatic material may have been deposited in the lake later. Under this organic horizon a carbonatic pale-olive to pale-yellow clay is present. The A 1 horizon has a moderate thick platy structure; the deeper layers are massive and structureless. Lime concretions have been recorded below the organic horizon; locally, at depths over one metre, gypsum has been found. Shells and shell fragments occur throughout the profile but especially in the organic horizon.

The watertable is 1 to 1.50 m. The high watertable has resulted in high salt contents, so that vegetation is halophytes and poor grasses, suitable only for ranging cattle.

Locally the Süleyman Hacı soils are covered by small dunes of carbonatic material (marl). This is so east of the Village of Taşağıl.

These soils always have an ochric epipedon. They are classified as Hapludents, or (according to the USDA system) as Calcisols.

The *Ahmet Hoca series* (Lm 5) occurs solely north-north-west of the Village of Taşağıl, at an altitude of about 1005 m. An example gives Profile No 31 (fig. 17).

Its soils are deep, with a shallow grayish-brown surface layer on light-gray car-

Soil description of Profile No 31.

Ap	0– 22 cm	grayish-brown (10YR 5/2) clay-loam; weak fine-subangular-blocky structure; soft when dry, very friable when moist, slightly sticky and not plastic when wet; common mesopores, few macropores; lower boundary abrupt, smooth.
A 1	22– 41 cm	light-brownish-gray (2.5Y 6/2) silty-clay; moderate medium-subangular-blocky structure; slightly hard when dry, very friable when moist, sticky and slightly plastic when wet; common mesopores, few macropores; lower boundary gradual, smooth.
AC ca	41– 57 cm	light-gray (2.5Y 6/2) silty-clay; weak medium compound prismatic and sub-angular-blocky structure; slightly hard when dry, very friable when moist, sticky and non-plastic when wet; common mesopores and macropores; few distinct white lime veins, few small lime concretions; lower boundary gradual, smooth.
C 1csca	57– 90 cm	light-brownish-gray (2.5Y 6/2) silty-clay; moderate medium-angular-blocky structure; slightly sticky and plastic when wet; few mesopores, common macropores; many prominent medium white lime and gypsum mottles; few distinct lime concretions; few krotovinas (6 cm); lower boundary abrupt, smooth.
(II)C2csca	90–130 cm	grayish-brown (2.5Y 5/2) silty-clay; moderate fine-angular-blocky structure; slightly hard when dry, firm when moist, slightly sticky and plastic when wet; common mesopores and macropores; many prominent medium lime and gypsum mottles, many big platy gypsum crystals.

This profile has an ochric epipedon and a calcic horizon.

bonatic silty-clay with weak prismatic and moderately fine angular-blocky structure. Distinct lime and gypsum mottling is frequent and (especially deeper in the profile) there are many big platy gypsum crystals. The watertable is 150 cm and less.

In general these soils are flat and level, but swampy depressions also occur.

They have to be classified as Calciorthids or, according to the USDA system, as Calcisols.

The remarkable accumulation of gypsum and lime presumably occurred at the beginning of the soil-ripening process (when the water slowly retreated). During that period the plants continued to take up salt from the soil water which was released from their dead parts onto the soil surface where it has remained because of the dry climate and salt has continued to accumulate from the groundwater.

Where the groundwater is nearer to the surface, i.e. when the capillary action of the soil brings the water to the surface, the explanation is simple; the continuous upward transport from salt or brackish water due to the dry climate (in which evapotranspiration always exceeds precipitation) causes accumulation of salt in the surface soil. This is common feature in arid regions.

4.3.3 Lr Ridge soils

The sandridges are considered remnants of old lakeshores and barrier beaches of the former Pleistocene lake. They occur in many places along the borders of the Great Konya Basin, always near the 1010 m contour line. In the Çumra Area they form small ridges along the present Konya Basin borders and dominate the landscape as they are 5 to 20 m higher than the surroundings. They are 50 to 400 m wide. One of them crosses a large part of the Çumra Area (from the villages of Kaşınhanı to Fethiye and farther eastwards). Another is found in the east of the area between Demirkent and Karahüyük, and a third is along the northern border of the terraces near Okçu and Türkmençamili, locally interrupted by wide eroded gullies and gradually grading into a shallow sandy layer covering a soft limestone subsoil. The ridge crossing the area from north-west to south-east and fanning out into a flat sand plain in the east, is probably also formed under lacustrine conditions. Sand is also observed in the subsoil of the Çarşamba clays occurring in the same area; it represents an old sandplain covered later by finer sediments.

Locally the ridges contain shells in the subsoil (mainly *Dreissenia*) and layers of coarse and fine gravel, often quarried, e.g. near Fethiye and north of Çumra. In an excavation near Kaşınhanı the sandridge was deposited on a soft lime sediment.

The ridge soils are deep and dark-grayish-brown, ranging from sandy-loam to sand. Mainly they are massive and structureless, weak subangular elements being noticed in loamy layers only. In all profiles gravel of different sizes was recorded. A calcic horizon commonly occurs. The carbonate content usually varies between 10 and 25%. In these soils biological activity is poor, predominantly rodent (*Citellus*). The ridge soils have good natural drainage, being porous, permeable and elevated above their surroundings; as a result ridge soils have not been subject to any saliniza-

tion. Though they are chemically very poor, they are among the oldest cultivated areas and therefore have homogenized dark profiles, in particular east of the River Çarşamba. Some are irrigated but dry-farming is most practised: cereals, sunflower, grapes and potatoes. Near the Village of Kaşınhanı they are used for horticulture, good irrigation water being available there from wells.

The ridge soils have been mapped in two series: the Fethiye series, uniform, sandy only, or incidentally with loamy layers (Lr 1), and the Karaarslan series, gravelly sandy-loam, stratified (Lr 2),

The *Fethiye series* (Lr 1) occurs at an altitude between 1005 and 1010 m. It includes soils consisting of dark-grayish-brown deep sandy-loam and loamy-sand with locally much gravel. They are massive or consist of single grains and lack any macro-structure except for some incidental loamy layers. A colour B horizon is common between 20 and 60 cm and at about 90 cm a calcic horizon may be present. Near Lake Hotamış gypsum was recorded as abundant white veins or big clusters at a depth beneath 180 cm.

Partly the Fethiye soils have to be classified as Normipsamments, or (if the profile has distinctly developed and its texture is sandy-loam or finer) as Ustochrepts. In the USDA classification they are denoted as Regosols.

The series was mapped in 3 soil phases on topographical differences: a high (Lr 1.1), a low (Lr 1.2) and a low and flat phase (Lr 1.3). Profile 18 (fig. 18) belongs to the first.

The *Karaarslan series* occurs south of Fethiye and around the Village of Okçu. Its soils differ from the preceding in being stratified loam and sand. They are deep and mainly brown and grayish. Lime pendants on medium and coarse gravels are common. Profile development is weak and limited to some pseudomycelium in the surface soil or prominent soft lime pockets and concretions at a depth of about 70 cm forming a calcic horizon.

They were mapped in two phases, again based on topography: a low phase (Lr 2.1) and a low and flat phase (Lr 2.2).

4.3.4 Lp Sandplain soils

The sandplains roughly cover the eastern part of the main sand area east of the River Çarşamba, north and east of the Sarlak Hüyük near the Village of Üçhüyükler and between the villages of Güvercinlik and Ürünlü; a third plain is found south of Taşağil. Though large parts are indeed entirely sandy, locally the surface soil contains loam or is covered by fine textured fluvial sediments. The sand is calcareous to very calcareous (carbonate contents varying between 5 and 40%) and often mixed with shells and shell fragments indicating its affinity with the ridge soils. The fact that the soils are very flat and level points to their formation under water.

The soils of this association range in texture from loamy-sand to loam, their colour varies from brown (surface soil) to light-brownish-gray. In general they are massive and show a single-grain structure, though incidentally heavier textured patches occur

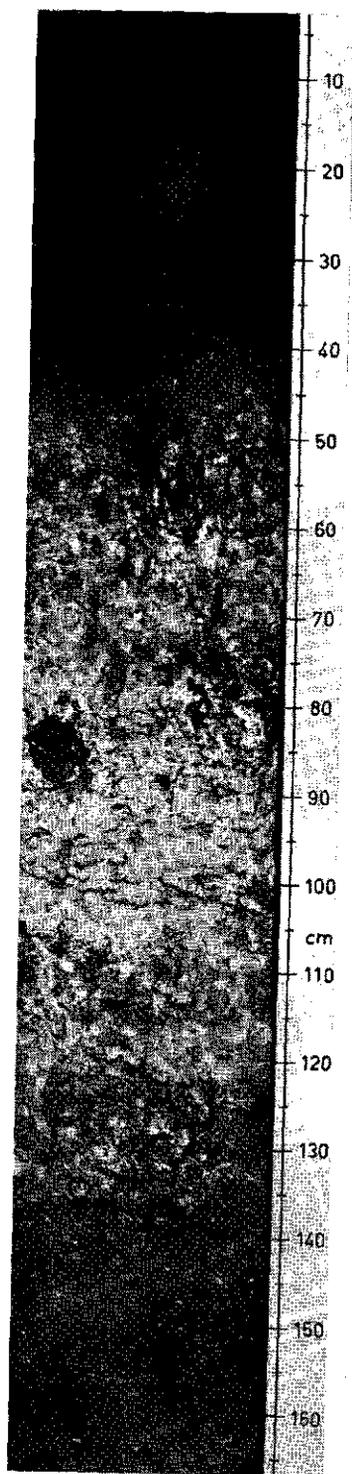


Fig. 19. Profile No 6.

Şekil 19. Profil no 6.

Lp 1.1: Well drained sandy soil, Sarlak series, sandplain soils

Konya Basin, Çumra Area, 64.7°N, 91.6°E, alt. 1010 m,
5-6-1964 (van Blom)

Geology: calcareous sand, presumably derived from beachridge

Physiography: sandplain

Relief: normal

Slope: level

Stoniness: class 0

Hydrology: well drained, watertable 3.50 m

Moisture: dry

Salinity: non-saline

Biological activity: roots common to 43 cm, considerable
activity of rodents

Vegetation: grasses and camelthorn

Land-use: cattle ranging

Classification 7th Appr.: 1964 Calciustollic Calciorthid

1967 Mollic Calciorthid

Five phases have been distinguished, based on texture, subsoil and drainage conditions:

sandy soil, deep	
well drained	Lp 1.1
imperfectly drained	Lp 1.2
moderately well drained	Lp 1.3
loamy soil	
with finer subsoil, imperfectly drained	Lp 1.4
complex with stratified subsoil	Lp 1.5

Profile No 6 (fig. 19) gives an example of a well drained soil (Lp 1.1).

The *Güvercinlik series* (Lp 2) occurs at about 1008 m. Its soils are flat and level and consist of dark-grayish-brown to pale-brown sand and loam. In the loamy soils, presumably influenced by floods of the River Çarşamba, the structure is often very coarse prismatic whereas the subsoil is often massive and structureless. At a depth of about 70 cm a calcic horizon is common, consisting of distinct fine and medium mottles. In general the soils are wet due to the application of abundant irrigation water resulting in a watertable at about 1 m. Main crops are cereals and melons.

Two phases have been mapped: deep loamy and imperfectly drained (Lp 2.1) and moderately deep loamy over sandy subsoil, moderately well drained (Lp 2.2).

4.4. M Miscellaneous land types

Besides the preceding 3 land types, for which a consistent soil classification could be drawn up, 6 land types were distinguished that were not treated in detail as they are hardly of any importance for agriculture because of their rare occurrence, special characteristics or inaccessibility. Brief treatment will suffice.

Soil description of Profile No 6.

- A 1 0– 10 cm very dark-grayish-brown (10YR 3/2) calcareous sand; massive and structureless; soft when dry, very friable when moist, slightly sticky and non-plastic when wet; common mesopores, few macropores; common roots of various sizes; few distinct fine shell fragments; lower boundary clear, smooth.
- A 12ca 10– 43 cm do except for a somewhat lighter colour and the presence of few fine faint white lime spots; lower boundary gradual, irregular.
- ACca 43– 97 cm light-gray (10YR 7/2) very calcareous sand; massive and structureless; very hard when dry, firm when moist, sticky and slightly plastic when wet; common mesopores, few macropores; few fine distinct shell fragments; abundant distinct lime concretions and spots of various sizes; common krotovinas; lower boundary gradual, wavy.
- C 1a 97–137 cm do, except for somewhat less lime and for a coarser texture; lower boundary gradual, wavy.
- C 2ca 137–170 cm grayish-brown (2.5Y 5/2) calcareous sand; single grain and structureless; soft when dry, very friable when moist, slightly sticky and non-plastic when wet; common mesopores, few macropores; common shells fragments; few prominent medium lime concretions throughout the horizon.

This profile has a mollic epipedon and a calcic horizon.

Ml Limestone uplands. In the limestone uplands the peaks and steep slopes have practically no solum, or the soils are shallow and cobbly (lithosols) except for local depressions filled with limestone material which are too small to be of real importance for agriculture.

Ms Colluvial slopes. The colluvial slopes of the limestone mountains occur only locally in the south-western parts of the area. Their soils predominantly have a loamy texture and contain limestone boulders and stones of different sizes. Where soil is present in reasonable quantities it has a loamy texture with only slight soil-formation. Basically these soils are very well suited for agriculture if water is available, especially in the south-western part of the Çumra Area where they are relatively flat. Dry-farming is practised here but those are exceptions: as a rule they are too stony and too steep.

Mc Creek bottoms. Some narrow and curving depressions were mapped which are most probably old river channels of the River Çarşamba system (Ac). They are clearly visible in the field and on aerial photographs. The soils of these creeks are very complex and their profiles contain layers of coarse sand as well as of heavy-clay. They are too young to have visible signs of soil formation. Where they are cultivated the yields are badly affected by waterlogging and salinization. Creeks of this kind were mapped in Çarşamba deposits only.

Another important creek system was encountered in the marl soil area (Lm) in the north-eastern part of the surveyed area. Presumably it represents the remnants of old gullies that drained off the water from the northern plain into Lake Hotamış. These creek bottom soils form a complex of poorly drained clayey and loamy soils.

A third small creek system of clayey and very salty soils is found some 6 km north-west of Dedemoğlu.

Mm Marshes. The marshes are the remnants of part of the former Lake Hotamış which is now very shallow and full of reeds and waterplants. In summer border-marshes are hardly accessible, in winter they are flooded. Short grasses and bunches of *Juncus* spp. are found there. They are entirely unsuitable for agriculture.

Mh Ancient dwelling sites (hüyüks). The old habitation sites or hüyük, are mounds up to 30 m high of ancient dwellings. Many of them are scattered all over the Great Konya Basin. As a rule their soils are dark-brown, loamy, very rich in phosphorus and mixed with pieces of pottery, bricks and bones. Recent studies on the famous Çatal Hüyük showed that their age may exceed 8000 years (Mellaert, 1964 and 1966).

If not too steep, the hüyük soils are used for agriculture, wheat and grapes being the main crops.

Here and there, usually near the hüyük, are small areas unlike the mounds but with obviously man-made soils. They have been included in the map under Mh.

Mg Cobbly gullies. Cobbly gullies have been mapped in the west of the Çumra Area. They are formed by erosion of the terraces and their soils are closely related to the bajada soils as the gullies are the channels through which the bajada material is transported. Their bottoms consist of a very young complex of shallow cobbly soils

generally of clayey texture and weakly profiled or not at all.

Because of their limited area and their stoniness these soils are not important for agriculture.

5. Salinization and alkalization

Large parts of the Great Konya Basin are, in one way or another, affected by salt, mainly due to poor drainage or excess irrigation water. Especially in the low centre of the plain the evaporation causes the accumulation of large quantities of salts in the soil, resulting in phenomena such as crust formation at the surface and efflorescence of salt in the profile.

In many cases evidence for (often local) salt accumulation cannot be found by merely studying the profile, so that laboratory investigations have to be carried out. In the beginning, many soil samples were transported from Turkey to Holland to be analysed in the laboratories of Wageningen. But as this procedure was possible only for a limited number of samples, in 1965 a fully equipped mobile laboratory was taken to Turkey to collect the required data on the spot. Notwithstanding the fact that only two months were available (July and August) for the field analyses, a good insight in the degree and nature of the related problems in the Basin could be obtained.

Soil salinity is not an inherent soil characteristic. It may disappear after proper measures. The degree of salinity is therefore indicated on the soil map by a grid of dots, independent of soil unit boundaries.

5.1 Salinity

In the Çumra Area salinization of the soil roughly occurs north-east of the Konya-Karaman railway. Both external (salt efflorescence at the surface) and internal (salt deeper in the profile) salinization are common. Of the external solonchaks several types have been recorded.

Flooded solonchaks are formed in the depressions in which surface run-off water from the surroundings collects. They are found in the northern soft lime soils; fig. 20 shows such a flooded solonchak.

After the water has evaporated, a salt crust, usually consisting of sodium sulphate and sodium chloride, forms in which several types of salt efflorescence can be distinguished. Most common are those which have the appearance of a cauliflower; their irregular surface is probably due to tensions caused by changes in the quantity of water of crystallization. The amounts of such water do not change only with the moisture fluctuations in the air, but depend also on the distance from the surface of the crust. On the surface a white powder is formed which loses much of its water by evaporation so that small particles loosen themselves from the soil; in the neighbourhood of flooded solonchaks aeolian transport of salt is indeed often observed.

Fig. 20. Flooded solonchak near Kaşınhanı.



Şekil 20. Kaşınhanı yakınlarında istila solonçak.

Under the dry surface a layer of crystals occurs which remains wet, as it is protected by the upper 'evaporation seal'. A sample taken from it rapidly dries and also becomes powdery.

The 'seal' explains why saline soils with a surface crust are often moist (resulting in bluish colours in the profile), whereas in neighbouring places the soil is entirely dry with a cracked surface (fig. 21). The amount of salt in the soil may be the same in both cases; table 10 shows a case in which it is even higher in the deeper layers.

Another form in which the surface crust may appear is that of a glass-like layer, again sealing the underlying soil (fig. 22).

The *puffed solonchaks* are rich in sodium sulphate. With the ascending groundwater this salt is transported to the surface of the soil where the water evaporates and needle-shaped crystals are formed. The crystals require more space than the soil is able to provide so that the soil particles are pushed aside and a loose surface soil is formed (Buringh, 1960). Fig. 23 shows the resulting salt-clay mixture.

In the Çumra Area such puffed solonchaks are found north of the Village of Dedemoğlu.

In general this type of salinization occurs spotwise; the reason for this is hard to find. A striking feature is the higher carbonate content of the surface soil in the non-puffed parts; there, prismatic and angular-blocky structures occur.

In such cases drying out of the soil and ploughing will result in a crumb surface layer prohibiting a too strong evaporation and thus preventing salinization.

A second important factor is the speed with which the groundwater reaches the surface soil. Formulas have been developed for a number of American soils by Rijtema (1965) and by Talsma. But application on the situation in Turkey is as yet impossible since some of the parameters used are not known. These formulas change with such factors as texture and moisture tension, whereas the Russian formula gives a value insufficiently adapted to local circumstances.

The third factor influencing salinization is the chemical composition of the salt dissolved in the groundwater. The solubility product causing precipitation differs for different compounds, as e.g. sodium sulphate is much less soluble than calcium chloride. This leads to the formation of zones above the groundwater in which one particular salt dominates. The solubility of sodium sulphate, an important component in most soils of the Çumra Area, is strongly influenced by the temperature of the soil which varies between 0° and 35°C. The solubilities of the most important salts measured in the Çarşamba deposits near Çumra are given in fig. 26.

In winter sodium sulphate is relatively slowly removed, as in this season it is much less soluble than in summer. This results in a quick accumulation in summer, whereas the slow removal in winter causes an increase in the amount of sodium sulphate. Therefore leaching of the soil is most effective during summer.

Methods to keep the amount of salt constant have been developed by Hulsbos and others (see Dieleman, 1963). Leaching formulas, however, are much more compli-

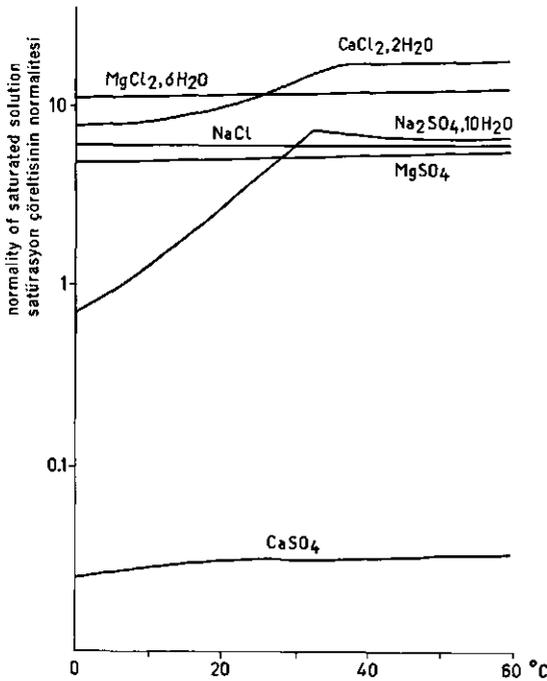


Fig. 26. Solubility of salts, after J. Bjerrum *et al.*

Şekil 26. Tuzların çözünürlüğü, J. Bjerrum ve arkadaşlarına göre.

cated; efforts in this direction have been made by van der Molen (1956), who adapted a model theory set-up for chromatographical purposes by Glueckauf.

In the following the salinity situation in the Çumra Area will be discussed. But as in general salinity is not correlated with the lower soil units and factors of geographical, hydrological and agricultural nature related to the landscapes very much influence salinization, the associations will be separately treated.

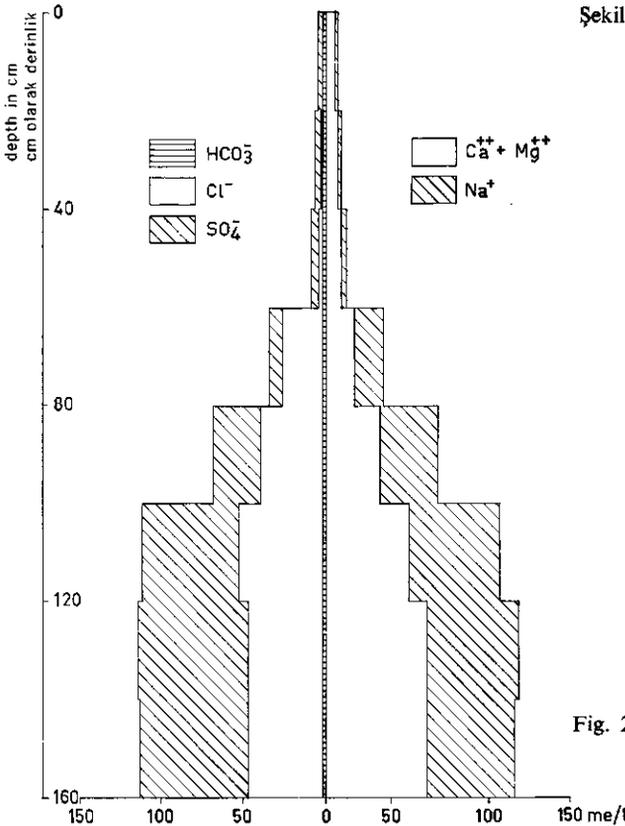
5.2 Salinity of each soil association

All *terrace soils* show the characteristics of a non-irrigated area with a deep water-table. Their surface layers are non-saline but the deeper layers may contain over 100 meq salt per liter of the saturation extract (fig. 27).

According to the classification of Kovda (1946) these soils belong to the Cl/SO_4 province, as the mayor part of the salts are sulphates while chlorides are of secondary importance.

Agriculture is not much influenced by this deep internal salinization.

The *bajada soils* are not or only very slightly saline. Only a few analyses have been carried out.



Şekil 27. Profil no 25'in iyon dengesi.

Fig. 27. Ion balance of Profile No. 25.

The *May fan soils* generally contain a low quantity of salts; near the apex of the *May fan* coarse textured non-saline soils occur. Near its base clay-loam is found with characteristics of an internal solonchak. Here seepage water from higher parts of the fan and irrigation water from the River *Çarşamba* cause accumulation of salt at depths of 70 cm and more (see fig. 28).

Sulphates dominate, but chlorides are also important. External salinity is rare; it occurs spotwise near the base of the River *May fan* in depressions and near irrigation canals where the watertable is high.

Partly the *Çarşamba fan soils* are very saline, especially near the drainage canals and in the lower parts of irrigated areas where pronounced external salinity occurs, caused by a high watertable and bad drainage conditions. A salt content of 865 meq/l has been measured in the groundwater. The salt consists mainly of sodium chloride and sodium sulphate, but other chlorides are also present.

Due to high evaporation rates (up to 6 mm/day) salt efflorescence quickly develops at the surface, especially along irrigation and drainage canals and in depressions. But where the applied irrigation water is properly drained no salinity has been recorded. Figs. 29 and 30 may serve as an illustration: the first profile (No 20) at the *Çumra* Experimental Station, the other some 3 km west of *Türkmen Karahüyük* between an irrigation and a drainage canal.

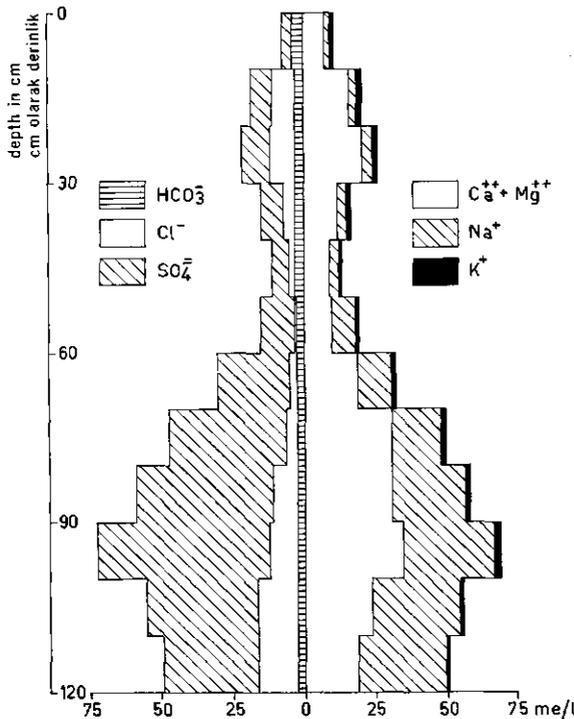
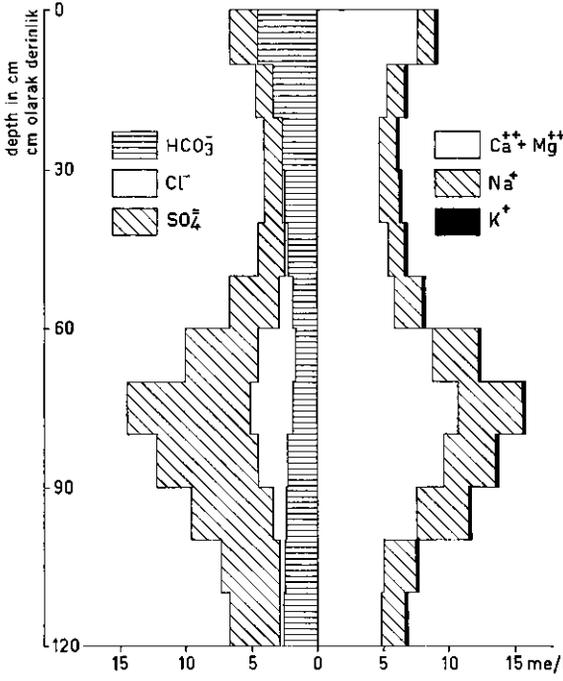


Fig. 28. Ion balance of Profile No 14.

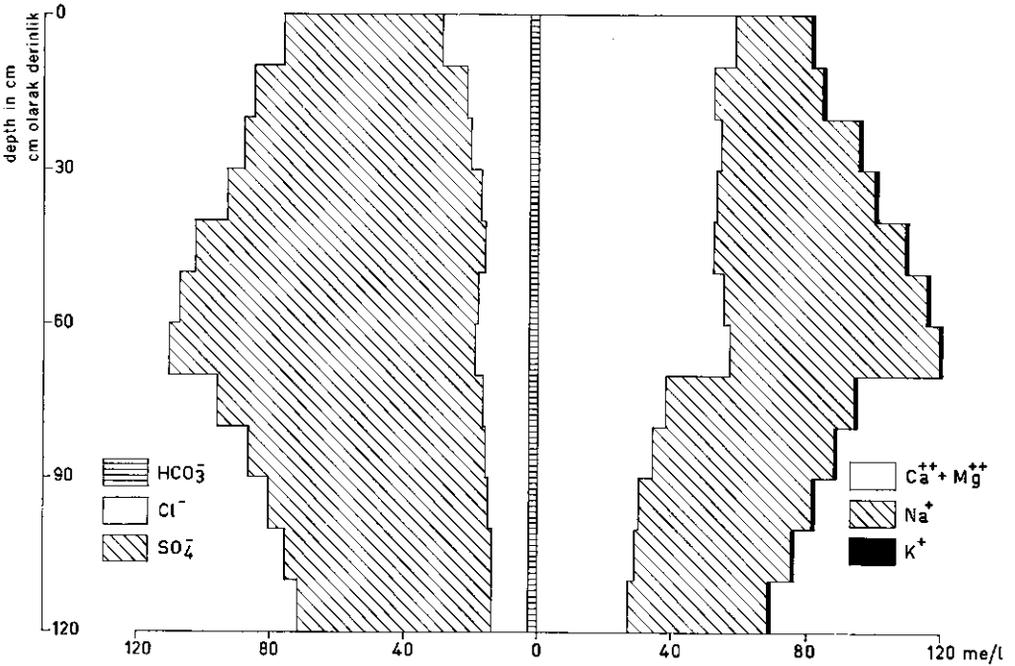
Şekil 28. Profil no 14'ün iyon dengesi.

Fig. 29. Ion balance of Profile No 20.



Şekil 29. Profil no 20'in iyon dengesi.

Fig. 30. Ion balance of Profile near Karahüyük.



Şekil 30. Karahüyük yakınlarında bir profilin iyon dengesi.

Most former backswamp soils are internally saline. Depending on their location the ions vary: in general sulphates dominate but spotwise a SO_4/Cl situation prevails, presumably due to the higher mobility of $CaCl_2$ and $MgCl_2$ as compared with Na_2SO_4 . Thus chlorides rise higher above the groundwater than sulphates; indeed sodium sulphate content proved to increase at depths over 2 m.

The dry surface soil with its wide cracks favours evaporation of the capillary groundwater to a depth of about 70 cm. There salt accumulates and efflorescences, chiefly of sodium sulphate, have often been recorded (fig. 31).

Locally accumulations of gypsum are found, especially in the brownish series (Ab 2).

Along the western border of Lake Hotamış, in the eastern part of the Çumra Area, clay dunes occur. As pointed out earlier, their high salt content (table 11) is caused by crumb-like aggregates which behave like sand if exposed to the wind.

Due to their relatively low situation, most of the soft lime soils are highly saline, though locally (e.g. in the surroundings of Ürünlü) less saline parts have been recorded.

Many of these soils are externally saline. They are not irrigated but the groundwater

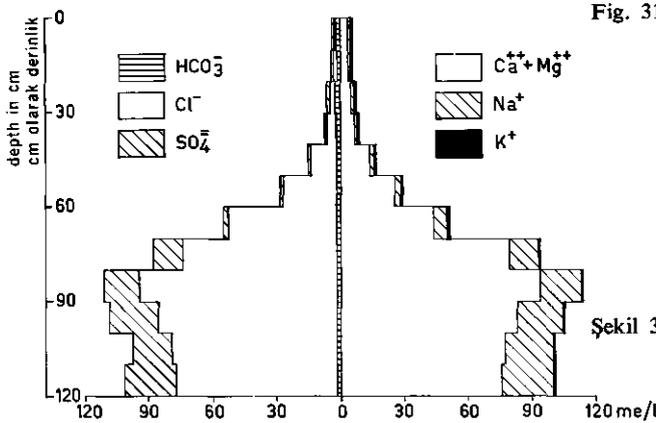


Fig. 31. Ion balance of Profile No 5.

Şekil 31. Profil no 5'in iyon dengesi.

Table 11. Electrical conductivity at various depths in clay dune soil.

Depth in cm	Electrical conductivity in mmho/cm
0- 10	4.16
20- 30	10.04
60- 70	25.07
90-100	23.23
120-130	21.32

Derinlik, cm	Elektriksel geçirgenlik, mmho/cm
0- 10	4.16
20- 30	10.04
60- 70	25.07
90-100	23.23
120-130	21.32

Tablo 11. Kil-eksibe toprağının çeşitli derinliklerinde elektriksel geçirgenlik.

is high enough to enable capillary water to reach the surface (fig. 32).

In flooded solonchaks only the upper 10 cm contains more salt than the adjacent areas not covered by a salt crust.

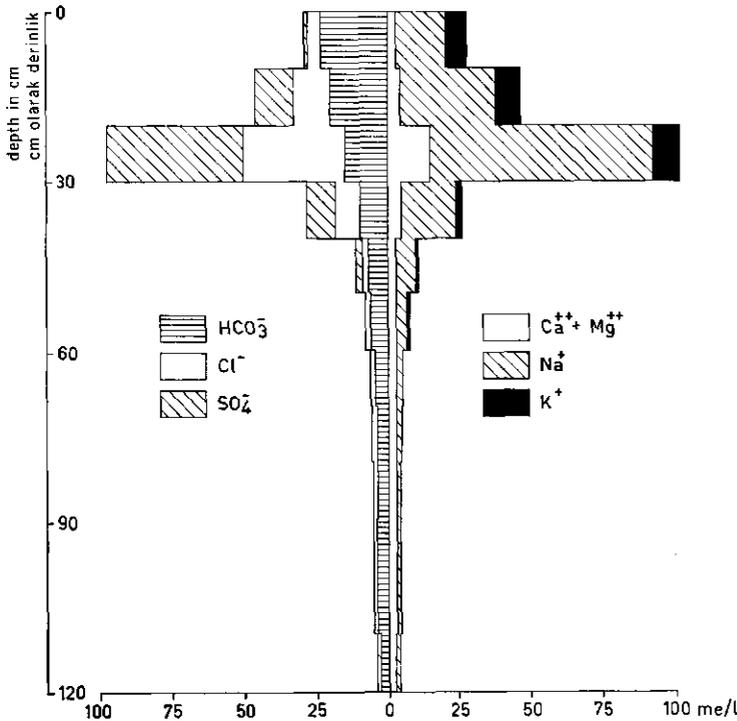
The high watertable in the northern soft lime plain is caused by seepage from the irrigated southern part of the Çumra Area and the western uplands. This seepage water, which receives much salt from the irrigated area, evaporates at the surface thus causing severe salinization. Since drainage is impossible, the northern soft lime soils are about the most salinized soils of the Çumra Area.

The salinity is of the Cl/SO₄ type. It prohibits any form of agriculture except extensive sheep ranging.

Many of the *marl soils* are strongly saline (sulphates being dominant) except the upper 70 cm which may contain only low quantities of salt as apparent from fig. 33, representing the situation in a profile that may be considered representative for all marl soils in the north-eastern corner of the Çumra Area. But this does not apply to the Serpil series in the extreme north, where they are surrounded by soft lime soils: here flooded as well as puffed solonchaks are found, both with distinct surface crusts.

Like the lime soils, the marl soils may suffer from spotwise salinization (fig. 34). In

Fig. 32. Ion balance of profile near Pireli Kas.



Şekil 32. Pireli kas yakınlarında bir profilin iyon dengesi.

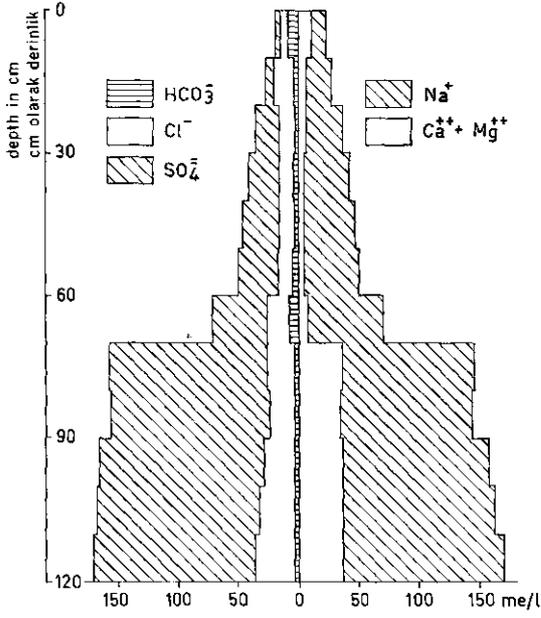
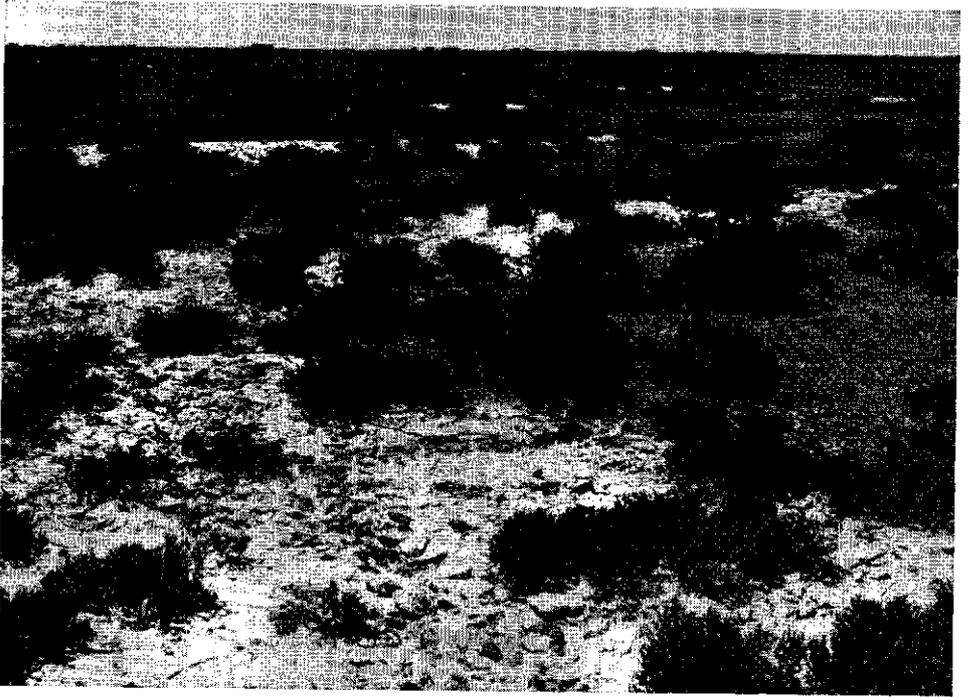


Fig. 33. Ion balance of Profile No 55.

Şekil 33. Profil no 55'in iyon dengesi.

Fig. 34. Puffed solonchak near Dedemoğlu.



Şekil 34. Dedemoğlu yakınlarında kabarık solonçak.

the puffed parts only the surface layer contains more salt than the non-puffed parts; deeper in the soil profile about the same amount has been measured in both profiles, as illustrated in table 12. The non-puffed part cracks strongly both in horizontal and vertical direction; presumably the horizontal cracks prevent the upper layer from becoming strongly saline although other explanations seem also possible and additional laboratory and field work has to be carried out to give a definite solution for the problem of spotwise salinization.

As expected, the high, sandy and excellent drained *ridge soils* are non-saline. All conductivity values measured are below 1 mmho/cm.

In general the *sandplain soils* north of the main sandridge are non-saline. They are highly permeable and the conductivity values are never over 1 mmho/cm.

In the southern sand plains places occur with hardly any salt, but investigations by Winkelmoen (1966) have revealed enormous fluctuations in salt content in the area west of the Village of Güvercinlik. These fluctuations are mainly due to the applied irrigation technique, which locally causes waterlogging inducing this high salinity.

Miscellaneous land types Except for the marshes, which are often inaccessible and do not have any value for agriculture, the land types grouped into this category are non-saline. The salinity of the marshes has often been observed in the field, but no laboratory investigations have been carried out.

Salinity map. The compilation of a detailed salinity map of the Çumra Area is hardly possible. Shallow and moderately deep internal solonchaks which hamper plant growth are difficult to trace because surface symptoms are lacking. Hence for a detailed map thousands of samples must be analysed. It is possible, however, to compile a sketch map from the available laboratory data and from the numerous more or less incidental observations in the field during mapping (fig. 35).

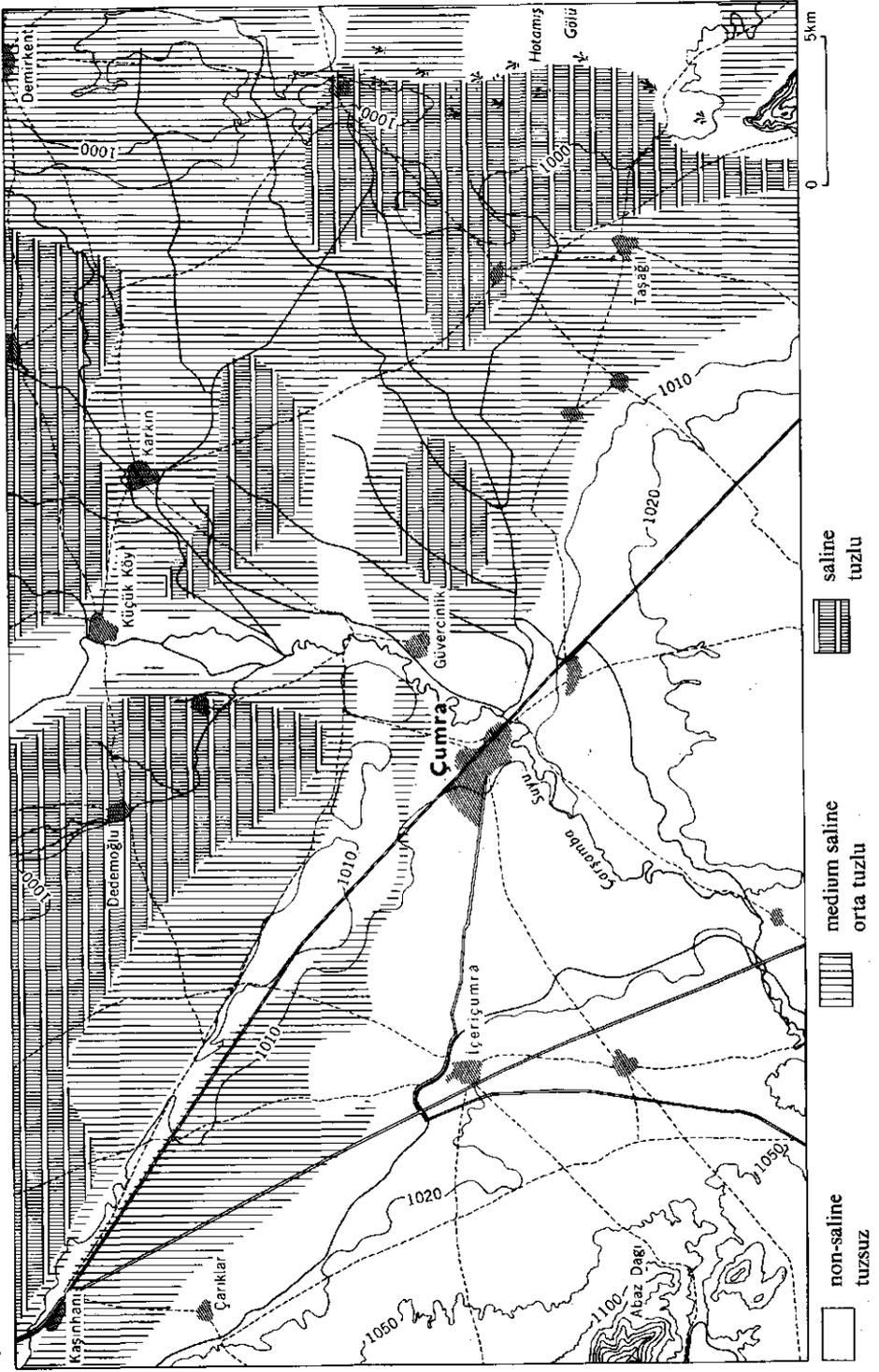
Three salinity classes could be distinguished. Spurious salt efflorescence can be observed after wetting and subsequent drying of a clod, though often a magnifying-glass is needed: it indicates an electrical conductivity value between 2 and 8 mmho/cm.

Table 12. Salt content of puffed and non-puffed sides of profile No 34.

Depth in cm	meq salt per litre	
	puffed solonchak	non-puffed solonchak
0- 10	1480	51.4
40- 50	1215	750
100-110	1460	1455
160-170	1680	1930
Derinlik, cm	yüzevi toz yapılı (puffed) solonçak	yüzevi toz yapısız (non-puffed) solonçak

Tablo 12. Profil 34'ün yüzevi toz yapılı (puffed) ve toz yapısız (non-puffed) kısımlarında tuz muhteviyatı.

Fig. 35. Salinity sketch map of the Çumra Area.



Şekil 35. Çumra bölgesinin kabaca tuzluluk haritası.

Below 2 the soil is not saline. Higher values are easily recognizable. Although the 2-8 mmho/cm class is often subdivided into two subclasses, this could not be achieved in the Çumra Area.

As salinization often occurs spotwise, the accuracy of these units in the map is locally low.

Internal and external solonchaks have not been separated. But, as pointed out in the descriptions of the salinity of each soil association, pronounced external solonchaks prevail in the waterlogged northern soft lime plain, near irrigation and drainage canals and near the western border of Lake Hotamış, whereas internal solonchaks are found in the backswamp soils, the marls and part of the swamp border soils. As a rule the soils at altitudes over 1010 m are non-saline: they are either not irrigated or they drain to the lower (northern) parts of the Çumra Area.

5.3 Alkalinity

Basically alkalinity is the phenomenon that more than a fixed percentage of the adsorption complex of the soil is occupied by Na^+ ions. Different handbooks give different limits, ranging from 7.5% to 15%. These high exchangeable sodium percentages (ESP's) induce a number of alterations in the soil that are of direct importance for agriculture. Clay particles with much adsorbed sodium are covered with a relatively thick water film. This film enlarges the distance between two given clay particles, thus lowering the attraction between the positively charged parts of one clay particle and the negatively charged parts of another. This means that clay aggregates are no longer kept together and thus the individual clay particles turn mobile. Decay of soil structure and eluviation of clay rapidly take place. The chemical determination of the ESP is complicated and time consuming. However, the amount of sodium adsorbed at the negative parts of the clay is a function of the chemical composition of the soil moisture, in equilibrium with the soil. This makes that, given the chemical composition of the soil moisture or saturated soil extract, the ESP can be estimated.

For the above mentioned moisture-complex relationship several physical formula have been developed.

Most commonly used is the relation between the ESP and the so-called Sodium Adsorption Ratio (SAR) which is defined:

$$\text{SAR} = \frac{\text{Na}^+}{\sqrt{(\text{Ca}^{++} + \text{Mg}^{++})/2}}$$

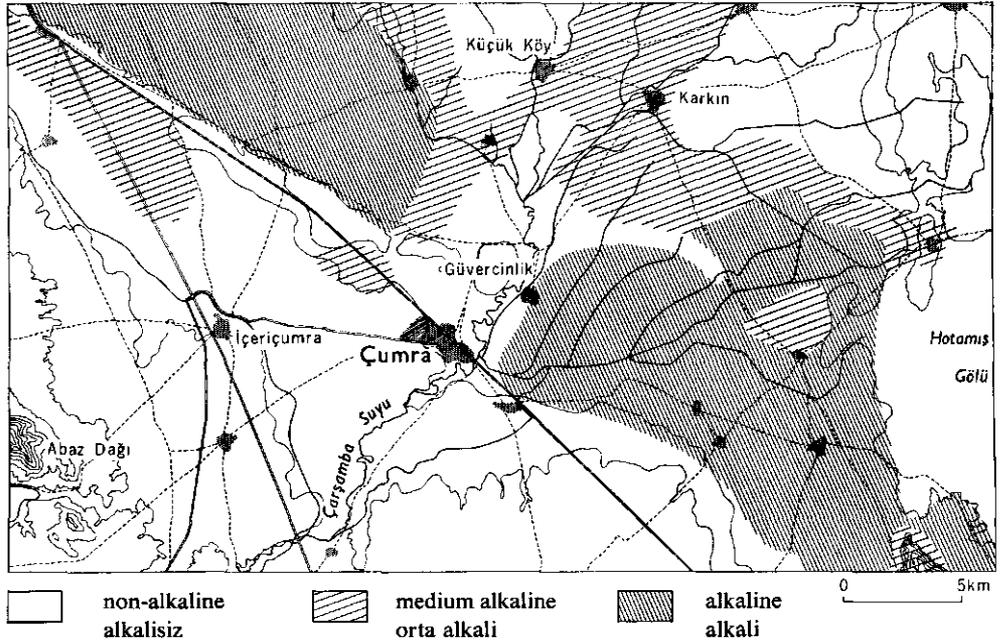
in which $\text{Na}^+ = \text{Na}^+$ in the soil solution in meq/l

$\text{Ca}^{++} = \text{Ca}^{++}$ in the soil solution in meq/l

$\text{Mg}^{++} = \text{Mg}^{++}$ in the soil solution in meq/l

A sketch map has been prepared (fig. 36) roughly indicating the areas with a $\text{SAR} < 4.5$, corresponding with ESP values < 5.0 (non-alkali soils), areas with $\text{SAR} = 4.5-17$ and ESP 5.0-20.0 (medium alkali soils) and areas with dominating $\text{SAR} > 17$ and ESP > 20.0 (alkali soils).

Fig. 36. Alkalinity sketch map of the Çumra Area.



Şekil 36. Çumra bölgesinin kabaca alkalilik haritası.

These SAR classes have been chosen to enable the use of data obtained at the salinity laboratory of the Agricultural University of Wageningen, Holland, and those collected by Reeve (1966), who investigated parts of the Çumra Area in the scope of a series of irrigation studies.

According to the map severe alkalinity only occurs in the lowest parts of the Çumra Area; in the south-west and north-east no alkalinity was observed.

In the Çumra Area alkali soils that are not affected by salt do not exist. In the saline parts sodium sulphate is the most important component of the salts present, which implies that much Na^+ occurs in the soil solution inducing high ESP values. Sodium carbonate, often mentioned as a Na^+ -source, is hardly found in the Çumra Area.

As sodium sulphate accumulates as a result of evaporation of seepage water from the surrounding mountains or from higher located irrigated parts of the area, severe alkalinity is nearly always found in combination with a high watertable. Partly these areas consist of soft lime soils with only some 10% clay. It is obvious that structure decay and clay eluviation are not very pronounced there, although ESP values over 50 occur. In these parts alkali soils are hardly recognizable in the field unless the profile contains organic matter which is not mineralized due to the wet condition. This organic matter, having an adsorption capacity which may exceed that of the clay, turns mobile if many Na^+ ions are adsorbed causing disperse humus illuviation in the subsurface soil.

The presence of gypsum in the soil prevents or hampers alkalization. Calcium ions from the gypsum are preferred by the adsorption complex over sodium ions. This probably explains the low SAR and ESP values measured in the marl plain in the very north-east of the Çumra Area which is locally very rich in gypsum.

The higher southern and western parts of the Çumra Area are not alkaline at all. Effective natural drainage allows adequate leaching during the wet winter and only in the deeper layers of the soil ESP values exceeding 10 are found.

Medium alkalinity is observed in parts of the River Çarşamba fan and its backswamps. Here alkalinity occurs spotwise, due to local differences in salinity and drainage conditions.

5.4 Alkalinity of each soil association

Summarizing, the alkalinity conditions of each soil association can be described briefly as follows:

The *terrace soils* are non-alkaline within 120 cm from the soil surface. Locally the deeper layers of the profile are saline-alkali.

In the *bajada soils*, just as in the terrace soils, no alkalinity has been observed in the upper 120 cm of the profile. But the subsoil may be slightly alkaline.

The *May fan soils* are non-alkaline except for some local spots at the very base of the fan. Here medium alkalinity has been observed deeper than 60 cm.

The higher located *Çarşamba fan soils* are non-alkaline. However, in the irrigation area west of this river saline-alkali soils are frequent, especially in the locally very saline depressions and along irrigation and drainage channels.

The majority of the *backswamp soils* are medium or strongly alkaline. This is due to their relatively low location causing poor drainage conditions and locally strong salinization, predominantly by $\text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O}$. However, part of the brown, moderately well-drained area west of Küçük Köy is not or only slightly alkaline. Here abundant gypsum has been observed.

In general the *soft lime soils* are badly alkaline. Estimated ESP values of over 20% are common. Spotwise high pH values occur, indicating the formation of soda (Na_2CO_3), which, next to Na_2SO_4 , contributes to the high Na^+ content of the soil moisture.

The eastern *marl soils* have proved to be non-alkaline in the upper 120 cm. North-west of Dedemoğlu, however, SAR values of over 60, indicating very high alkalinity, have been measured. Here puffed solonchaks consisting of almost pure $\text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O}$ occur, which explains the SAR values over 300 measured in the upper 15 cm. In the non-puffed places SAR values are considerably lower (12-71).

The *ridge soils* are non-saline and well drained. These soils are not subject to alkalinity in any degree.

The *sandplain soils* are non-alkaline in the upper 50 cm. However, in the subsoil the profile may be moderately alkaline. South of the sandridge the surface soil is locally alkaline as well; this part is wet during most of the year which results in high

salinity and alkalinity.

In general the miscellaneous *land types* do not show any alkalinity at all except for the marshes, which anyway are not important for agriculture.

6. Land-use and soil suitability

The classification of the soils as presented in the previous chapters is mainly based on physical and chemical characteristics of the soil itself, and any connection between soil types (in a general sense) and e.g. the future agricultural use possibilities and the natural vegetation were left out of consideration.

In this chapter, the present suitability for agriculture (including cattle breeding) will be treated, and the soils will be classified according to 'suitability classes', indicating the suitability for this purpose. Based on the USDA classification system eight such classes have been distinguished:

Suited for arable farming:

Class I: few limitations, very good land (total surface 30,400 ha)

Class II: moderate limitations or risks of damage, good land (total surface 32,300 ha)

Class III: severe limitations or risks of damage, regular cultivation possible if limitations are observed (total surface 26,300 ha)

Class IV: very severe limitations, suited only for occasional cultivation or for some kind of limited cultivation (total surface 7,700 ha)

Not suited for arable farming:

Class V: not suited for arable farming because of wetness, stoniness, etc.; few limitations for grazing (total surface 14,200 ha)

Class VI: too steep, stony, saline, wet, etc. for arable farming; moderate limitations for grazing (total surface 1,300 ha)

Class VII: very steep, stony, saline, wet, etc.; severe limitations for grazing (total surface 3,300 ha)

Class VIII: not suited for arable farming or grazing; suited for wildlife, watershed, etc. (total surface 3,200 ha)

This classification, being designed for US circumstances can only be used in this area because of the good knowledge of its soils and the fairly high development of its (mainly) irrigated agriculture. A suitability classification concerning the soils of the entire Great Konya Basin should be based on a different and adapted system (see de Meester, 1969).

In arable farming crop yields are decisive. They have been collected from various sources, but most of them from farmers, though the latter do not excel in reliability. The differences in judgement within one soil unit are not only caused by differences in soil management, the application of fertilizers and the use of different varieties, but also erratic information. As a rule the given data are too low, as the questioners have been considered with suspicion or mistaken for tax officers. But exaggerations also

occur. More reliable, though very limited in number, are the data from official sources. For wheat these data have been checked on a number of experimental fields included in soil fertility investigations covering the majority of the non-irrigated soils of the Çumra Area. But it has to be kept in mind that such data are unreliable in so far that they are influenced by annual fluctuations caused by variations in the climate. This is illustrated by the average sugar-beet yields obtained in the Çumra Area, as shown in table 13.

Table 13. Average sugar-beet yields in the Çumra Area, in tons/ha.

1963	1964	1965	1966
22.94	17.96	19.21	30.62

Tablo 13. Çumra bölgesinde ortalama şeker pancarı verimi, ton/ha.

For all these reasons the given suitability classes for the most important crops are more or less tentative. Moreover they are incomplete, as many combinations of soil type and crop do not occur, not only for purely agricultural reasons but also because planting a certain crop is economically not justified (e.g. vegetable growing on remote land).

6.1 Class I: very good soils, only few limitations for arable farming

In class I the best soils of the Çumra Area are grouped. They are irrigated or can be irrigated, they have excellent hydrological properties and are partly used for horticulture. Part of the River May sediments, of the River Çarşamba sediments, and the terrace and bajada soils belong to this class. In particular the following map units have to be mentioned:

Flat terrace soils: Te 1.1, Te 1.3, Te 1.4, Te 2.1, Te 2.2 and Te 4.1. All these soils are deep and have loamy or clayey texture. Investigations on soil peels as well as on thin sections have shown properties very favourable for root development. Measurements in the field have resulted in high permeability values (1 m/24 h) and a deep water-table in the coarse and calcareous subsoil which also favours drainage. Tillage offers no problem; the flat relief prevents severe erosion.

High crop yields are obtained on these soils. With suitable fertilizing and proper irrigation, sugar-beet yields from 25 to 35 tons/ha may be expected (average for the whole Çumra Area: 18-27 tons/ha). For dry wheat yields of 1 to 2.5 tons/ha are common, 4 tons is no exception with irrigation.

Bajada soils: Ar 1.1 and Ar 1.2. These bajada soils are deep or moderately deep over terrace subsoil. They have good agricultural properties and may give very high yields, especially if irrigated. Near the Village of Çarıklar sugar-beet yields of over

35 tons/ha have been recorded. Very high wheat productions are found: dry wheat without fertilizer 0.8-2 tons/ha, with fertilizer up to 2.8 tons.

May fan soils: Am 1.1, Am 1.2, Am 1.3 and Am 1.4. These soils are all clayey or loamy, deep or moderately deep over terrace soil. They show an excellent structure in combination with good porosity resulting in good permeability and very favourable conditions for root development.

Partly these soils are used for horticulture. If properly irrigated and well fertilized very high yields may be obtained, as shown in table 14. The fertilized crops are cultivated in the gardens near the Village of İçeriçumra; they are properly treated with insecticides and optimal microclimatic conditions are created by poplar windbreaks and shadetrees.

Non-irrigated crops have a considerable lower production. For wheat yields of 1 to 2 tons/ha have been noticed.

Çarşamba fan soils: Ac 1.4, Ac 1.6, Ac 1.9, Ac 1.10 and Ac 1.11. These deep clayey or loamy soils are well drained, not or only slightly affected by salt and very porous throughout the rooting zone. Almost all these Çarşamba deposits are irrigated. They are very suitable for cultivating a large variety of crops; cereals, sugar-beet and melons are the most common. Some tentative yield data from properly fertilized irrigated soils are given in table 15. If the soil is badly managed or if no fertilizer is applied, the yields may be considerably lower; near the Village of Uçhüyükler sugar-beet yields of only 5-10 tons/ha are common.

Table 14. Average yields on irrigated May fan soils (Alibey series), in tons/ha.

Sugar-beet / şeker pancarı	with fertilizer / gübreli	20 -40
Wheat / buğday	with fertilizer / gübreli	3.8- 4.5
	without fertilizer / gübresiz	1.5
Barley / arpa	without fertilizer / gübresiz	1.2- 2.8
Oats / yulaf	without fertilizer / gübresiz	1.2
Lucerne / yonca	with fertilizer / gübreli	40 -50
Melon, watermelon / kavun, karpuz	with fertilizer / gübreli	20 -24

Tablo 14. Sulanan Am topraklarında (Alibey serisi) ortalama mahsul miktarı, ton/ha.

Table 15. Some tentative yield data on properly fertilized irrigated Çarşamba fan soils, in tons/ha.

Sugar-beet / şeker pancarı	Wheat / buğday	Lucerne / yonca	Melons / kavun
20-46	1.5-2	up to 60	15-25

Tablo 15. Uygun şekilde gübrelenmiş ve sulanmış bazı tecrübe mahsüllerine ait kayıtlar Çarşamba topraklarında ton/ha olarak.

6.2 Class II: good soils with moderate limitations or risks of damage

In this class terrace soils, a bajada soil, River May deposits, River Çarşamba deposits and a number of backswamp soils are brought together. Their agricultural value is reduced by such circumstances as the presence of a less favourable subsoil, slight stoniness, suboptimal drainage conditions and some sloping.

Terrace soils: Te 1.2, Te 1.2, Te 3.1, Th 1.1 and Th 1.2. Mapping unit Te 1.2 differs from Te 1.1, which has been grouped in suitability class I, by being only moderately deep. This may affect plant growth, especially since these soils are usually not irrigated. The underlying very calcareous material is inferior as a rooting zone as far as water storage capacity and rootability are concerned. Unit Te 3.1 consists of clayey material mixed with angular rock fragments which may affect rooting and tillage. Depending on the application of fertilizers wheat yields of 1-2 tons/ha may be expected.

Units Th 1.1 and Th 1.2 are deep or moderately deep, undulating, and locally angular-cobbly. In spite of the favourable rooting conditions they have lost much of their agricultural value by erosion. They are not irrigated. Wheat is the main crop, producing up to 1.7 tons/ha.

Bajada soils: Ar 2.1. This clayey soil is moderately deep and has a soft lime subsoil. It forms a transition between Ar 1.1 (suitability class I) and the soft lime soils.

The bad properties of the soft lime in the subsoil are obvious from the differences in sugar-beet yield between Ar 1.1 and Ar 2.1: 35 and 13-24 tons/ha, respectively.

May fan soils: Am 2.1 and Am 2.2. These soils consist of sand and loamy-sand and they are partly irrigated. Only a few yield data are available: sugar-beet 8.5-14 tons/ha, wheat 1-1.5 tons (irrigated).

Çarşamba fan soils: Ac 1.2, Ac 1.3, Ac 1.5, Ac 1.7, Ac 1.8 and Ac 1.12. These soils have been grouped in suitability class II mainly for their less favourable drainage, the presence of a soft lime subsoil and their coarser texture. Partly they are affected by salt, spotwise even severely so. They are all clayey or loamy to a depth of at least 60 cm and their properties are favourable for root development and tillage.

On the units Ac 1.2, Ac 1.3, Ac 1.7 and Ac 1.8 production is lowered by a high watertable. In particular Ac 1.8 suffers from salinization, especially along the canals, so that for watermelons decreases in yield are known from 14 to 3 tons/ha within 10 years. Where the soil is not or only slightly saline high crop yields may be expected (some tentative data are given in table 16).

Table 16. Some tentative yield data for irrigated Çarşamba fan soils, in tons/ha.

Sugar-beet / şeker pancarı	not fertilized / gübresiz	15 -28
	fertilized / gübreli	up to 46
Wheat / buğday	not fertilized / gübresiz	1.2- 1.9
Watermelons / karpuz	fertilized / gübreli	15 -20

Tablo 16: Uygun şekilde sulanmış bazı tecrübe mahsullerine ait kayıtlar Çarşamba topraklarında ton/ha olarak.

Map unit Ac 1.5 is influenced by the occurrence of a soft lime subsoil beginning at depths between 40 and 80 cm. Irrigated wheat yields ranging from 1.2 to 1.9 tons/ha have been recorded here, depending on the application of fertilizer and probably also on irrigation technique and soil management.

Unit Ac 1.12 consists of sandy deposits. They are not saline but their agricultural value is somewhat lowered by their heterogenous composition. Data on yields are not available.

Former backswamp soils: Ab 1.1, Ab 1.2, Ab 1.3, Ab 1.5, Ab 1.6, Ab 2.1, Ab 3.1 and Ab 4.1. All former backswamp soils grouped into suitability class II are moderately well to imperfectly drained. They are moderately deep or deep and consist of clay or heavy-clay of the smectite type, involving swelling and shrinking that affects their porosity and the soil/water ratio, resulting in tillage and management difficulties. This, in combination with the bad drainage conditions, reduces their value for agriculture.

Almost all former backswamp soils are slightly affected by salt. In general the salt content increases suddenly at a depth between 1.50 and 2 m, but this does not harm plant growth to such an extent that a subdivision based on this difference is necessary.

Sugar-beet yields on irrigated soils ranging from 16 to 35 tons have been recorded; wheat production amounts to 1.5–1.9 tons/ha.

6.3 Class II: soils with severe limitations or risks of damage; regular arable farming possible if limitations are observed

In this class some terrace soils, a River May deposit, former backswamp soils, soft lime soils, marl soils, soils of the beachridges and sandplains are brought together. For all the agricultural possibilities are restricted, due to insufficient drainage (which may cause salinity), a sandy or bad structure or the very poor mineral composition. But if the proper measures are taken, regular arable farming is still possible.

Terrace gully soils: Tg 1.1 and Tg 1.2. These soils form bottom and slopes of a number of gullies dissecting the terraces south of Çumra in north-south direction. The gully-bottom soils (Tg 1.1) contain many stones, mainly angular fragments of the underlying Neogene limestone formation. The Tg 1.2 soils contain much less rock fragments, but they are subject to heavy erosion because of their steepness.

Both soils cover only a small area and are not important, except for the drainage of the surrounding terrace soils. Data on crop yields are not available.

May fan soils: Am 2.3. The coarse and gravelly soils of this unit form the river bed at the apex of the alluvial fan of the River May. Where irrigation water is available (along the river bed) various crops can be grown. In dry-farming only the cultivation of cereals is possible, usually with poor results because of the low water storage capacity of these soils. Exact data on yields are not available.

Former backswamp soils: Ab 1.2, Ab 1.7 and Ab 2.2. The agricultural value of these soils is low because of the poor drainage conditions. Large gypsum crystals and powdery gypsum pockets in the subsoil witness this situation. Although they are not very

saline at their surface, the salt content may be considerable between 1.00 and 1.50 m. Swelling and shrinking hamper plant growth and in addition these soils are too wet during a long period.

Only few crop data are available; they show sugar-beet yields ranging from 5 to 15 tons/ha and wheat productions up to 1.5 tons.

Soft lime soils: Lc 1.1, Lc 2.1 and Lc 3.1. All soft lime soils are strongly limited in crop production, mainly due to their high carbonate content which causes an ion composition unfavourable for plant roots. Phosphate deficiency is common.

The agricultural value depends mainly on the thickness of the nearly always present loamy or clayey surface layer. This layer may contain some organic matter which considerably improves the quality of the soil. Mainly depending on the application of fertilizers sugar-beet yields range from 14 to 28 tons/ha, wheat yields from 0.5 to 1.5 tons.

Marl soils: Lm 1.1, Lm 1.2 and Lm 3.1. Marl soils consist for about 60% of Ca and Mg carbonate and thus have much better properties than the soft lime soils which consist almost entirely of carbonates. These loamy or clayey soils are very porous and nearly always have an excellent structure. But phosphate fixation may be so strong that, even in soils in which phosphate abounds, little may be available for the plants.

Partly these soils are irrigated. Locally wheat is grown without irrigation; here the yield depends for an important part on the thickness and properties of the usually present dark surface layer and ranges from 0.3 (thin surface soil, not fertilized) to 1.5 (thick surface layer, fertilized) tons/ha.

Ridge soils: Lr 1.1, Lr 1.2, Lr 1.3, Lr 2.1 and Lr 2.2. All beachridge soils are grouped into class III. This does not mean that they are all completely alike but solely that their agricultural properties differ only slightly. These differences depend on the depth of the groundwater and the texture (loam and gravel content).

Without irrigation these soils are very poor, but when irrigated they may be highly productive: near Kaşınhanı, in the north-western part of the area, sugar-beet yields of 24 to 39 tons/ha are normal. Cereals, grapes and all kinds of vegetables can be grown as well. These soils are irrigated by pumping; they do not suffer from salinity because of the good natural drainage.

Sandplain soils: Lp 1.3, Lp 1.4, Lp 1.5, Lp 2.1 and Lp 2.2. All these soils are loamy, deep or moderately deep over sand. They may have good properties for plant growth, but the drainage conditions are usually bad, especially west of Çumra where they locally show severe salinization.

Data on crop yields are not available.

6.4 Class IV: soils with very severe limitations; suitable only for occasional arable farming or for some kind of limited cultivation

This class includes only a few soils. They are marginal and in the Çumra Area of no real importance for agriculture. An exception are the shallow undulating terrace soils

which cover a rather large area. Next to these terrace soils sandplain soils, colluvial slopes, creek bottoms and cobbly gully bottom soils belong to this suitability class.

Terrace soils: Th 1.3. Because this terrace soil is very shallow and very liable to erosion agricultural possibilities are limited. Irrigation cannot be applied and the storage capacity for water is low.

Cereals are almost the only crops grown. Wheat yields are estimated at only 0.3 to 0.8 tons/ha.

Sandplain soils: Lp 1.1 and Lp 1.2. These sandy soils are very poor and their surface layers are locally slightly saline, increasingly so deeper in the profile. Yield data are not available.

Colluvial slope soils: Ms. The colluvial slopes are grouped in class IV because the elevation at which they occur impedes irrigation and because they are often very stony so that agriculture is impossible. But on the relatively flat slopes in the south-western part of the Çumra Area dry-farming occurs.

Creek bottoms: Mc. These soils range in texture from sand to clay and the drainage conditions vary almost as much. Agriculture is still possible but of no importance because of its marginal character and the small area concerned.

Cobbly gullies: Mg. These gully soils occur in the western part of the Çumra Area. They are closely related to the bajada soils because they are the channels through which the material is transported that forms the bajada soils. They are rather complex and very stony and occupy only a small area. They are not very important for agriculture.

6.5 Class V: soils not suited for arable farming because of wetness, stoniness, etc.; few limitations for grazing

Representatives of this suitability class are only found among the soft lime soils in the north-western and south-eastern parts of the Çumra Area where they are covered by vast pastures with short grasses such as *Atropis distans* and *Cynodon dactylon*. This land is used for ranging sheep, goats, cattle, horses, donkeys and water buffaloes. It is too wet and locally too shallow for arable farming.

Soft lime soils: Lc 1.3, Lc 1.4, Lc 2.2 and Lc 2.3. All these soils consist of almost pure CaCO₃ with a shallow loamy or clayey surface layer. During winter and in early spring they are sometimes flooded, but most of the time they are well accessible.

6.6 Class VI: soils too steep, stony, saline, wet, etc. for arable farming; moderate limitations for grazing

Marl soils: Lm 2.1 and Lm 3.2. These soils are wet and hardly accessible during winter and early spring. Partly they are strongly affected by salt; in particular the Lm 2.1 soils suffer from excess sodium sulphate causing fluffy spots scattered over the area.

The vegetation consists of typical halophytes such as *Halocnemum strobilaceum*,

Salicornia herbacea, *Suaeda* spp. and *Salsola* spp.

6.7 Class VII: very steep, stony, wet, etc. soils; severe limitations for grazing

This suitability class includes only the marshes located in the eastern part of the Çumra Area.

Marshes: Mm. The marshes are flooded almost throughout the year and are suitable only for grazing horses and water-buffaloes, though the vegetation is hardly suited for that purpose as it consists (next to *Atropis distans*, *Cynodon dactylon*, *Aeluropus littoralis* and other grasses) for a large part of *Juncus maritimus* and reed.

6.8 Class VIII: soils not suited for arable farming or grazing; suited for wildlife, watershed, etc.

This class includes only the *limestone uplands: Ml*, of which large parts have no soil at all. Nevertheless there is some grazing of sheep and goats, mainly by nomads.

6.9 Discussion

It appears from the data given at the beginning of this chapter that more than half of the Çumra Area consists of good or very good soils. Table 17 supplies some more detailed information. It indicates that only some 40% of the area is irrigated and that some 30% consists of irrigated good to very good soils. On the other hand, about 20% of the area is occupied by soils of suitability classes I and II that are not irrigated. Although the supply of irrigation water is not possible everywhere, a considerable part of this 20% may still be irrigated without too many difficulties. This will mean a

Table 17. Percentages of the Çumra Area covered by irrigated and unirrigated soils for each soil suitability class.

Class / sınıf	Total area / toplam	of which irrigated / sulanan	of which not irrigated / sulanmayan
I	25.4	12.9	12.5
II	26.9	18.0	8.9
III	21.9	7.9	14.0
IV	6.5	0.5	6.0
V	11.9	0.0	11.9
VI	1.9	0.0	1.9
VII	2.8	0.0	2.8
VIII	2.7	0.0	2.7
Total	100.0	39.3	60.7

Tablo 17. Çumra bölgesinin sulanan ve sulanmayan topraklarının her arazi kabiliyet sınıfı, tarafindan örtülen yüzdeleri.

substantial increase in production.

Some 20% of the Çumra Area is occupied by soils with severe or very severe limitations for agriculture. The main causes are waterlogging and high salinity.

The remaining 20% is not suited for crop production due (next to wetness) to poor mineral composition of the soil (mainly the high carbonate content, 60 to 90%).

Summary

The Çumra Area is the district around the Village of Çumra in the Great Konya Basin of Central Anatolia. It covers about 100,000 ha. During the field seasons of the years 1964-67 a semi-detailed soil map of this area was made as part of a research and training programme for Turkish and Dutch students supervised by Ir T. de Meester (1964 and 1965) and Ir P. M. Driessen (1966) and directed by Dr P. Buringh, Professor of Tropical Soil Science, Agricultural University of Wageningen (the Netherlands), which University sponsored the project. For the survey, topographic maps and aerial photographs were provided by the Turkish Government. As a result a soil map on the scale 1 : 100,000 was produced.

The climate of the Çumra Area is semi-arid with a dry warm summer and a cold winter. Annual evaporation exceeds precipitation.

The area is cultivated, except for some low and partly marshy areas in the north-western and south-western corners. The latter are used for sheep and cattle ranging.

Physiographically, 10 major land types can be distinguished; another 6 of minor importance have been gathered into one category called miscellaneous land types.

For the soils the following subdivision has been drawn up.

Soil descriptions

Te Flat terrace soils. In general the flat terrace soils are deep and loamy, ranging from brown to very pale-brown, with yellowish colours deeper in the profile. They have a well developed B horizon as well as a calcic horizon with powdery pockets and hard concretions between 40 and 80 cm. Deeper than 130 cm a gypsic horizon with either hard clusters or fine white crystals is often present. Almost all have a very calcareous subsoil consisting of pieces of hard and soft lime.

Th Undulating terrace soils. The soils of the undulating terraces are mainly shallow or very shallow and angular-cobbly with a distinct calcic horizon between 20 and 30 cm. The profile may be truncated by erosion. Partly these soils are under dry-farming.

Tg Terrace gully soils. The terrace gully soils comprise gully bottom soils and gully slope soils. They vary in depth and their profiles are not or only weakly developed. The gully bottoms are cobbly and very complex; the gully slopes are shallow, locally with limestone outcrops.

Ar Bajada soils. The bajada soils are in general deep and clayey with a brownish surface soil over a yellowish-red solum. A well developed B horizon, 60 cm or more

thick, begins between 30 and 40 cm. In deeper layers slickensides are common. In the subsoil lime enrichment occurs. Here and there a carbonatic subsoil is present if the bajada is deposited over terrace soil.

Am May fan soils. The May fan soils are in general deep and range in texture from coarse sand and gravel to loam and clay. Locally a stratified subsoil is present. They are uniformly brown to grayish-brown or dark-brown and have a weak or moderately subangular-blocky structure though locally blocky and even prismatic structures occur in the Ap and C horizon. In the clayey and loamy soils 'clay-balls' (round relatively fine-textured elements up to 1 cm in diameter) are common. Lime segregation occurs at depths between 50 and 80 cm.

Ac Çarşamba fan soils. The Çarşamba fan soils are moderately deep or deep with uniform brown to dark-brown colours. They are predominantly clayey or loamy. Angular-blocky and prismatic structures are common, in the subsoil cutans of illuvial clay may be present. Although all these soils contain lime, a real calcic horizon has not been established. Former root channels, various biopores, mesopores and macropores make the profile very permeable. Dotted about are sandy subsoils and even completely sandy profiles.

Ab Former backswamp soils. The former backswamp soils are deep and range in texture from heavy-clay to loam. They vary from dark-yellowish-brown and brown to light-brownish-gray and dark-gray, even sometimes almost to black. They swell and shrink much and have a churned surface layer. A distinct structural B horizon with strong coarse angular-blocky and prismatic structures underlies an A horizon containing subangular structure elements. Pronounced slickensides occur in the subsoil. Here and there self-mulching and churning soil was observed. Secondary lime formation is weak: only a few faint concretions or fine white mottles are found. Veins, mottles and clusters of gypsum are commonly present. Locally there are shell fragments of *Dreissenia* and *Planorbis* in the subsoil.

Lc Soft lime soils. The soft lime soils have a carbonate content which may be as high as 90 %. In general the thin A horizon of very calcareous loam or clay is grayish-brown to dark-brown. Here and there the white soft lime is covered by shallow backswamp deposits fanning out over the lime plain. Although B horizons are sometimes found, the A horizon usually overlies the unchanged soft lime parent material, which may be concretionary. Some profiles have sandy or silty material in the subsoil. Depending on the texture of the surface soil the structure ranges from weak subangular-blocky to strong coarse prismatic. The subsoil is invariably massive and structureless. Both secondary lime (calcic horizon) and gypsum segregation are present. Locally solid Neogene limestone occurs in the subsoil.

Lm Marl soils. The marl soils are deep and silty or they consist of carbonatic silty-clay-loam. Locally they are stratified with fine sandy layers. They range from dark-grayish-brown to pale-olive and white. In general they have an A horizon with weak platy structures and a B horizon with fine and medium subangular-blocky elements, prismatic and angular-blocky structures being recorded as well. The subsoil has compound prismatic and fine angular-blocky elements. The soils contain up to

60% carbonate. Often there is a calcic horizon with white lime pockets, concretions and mottles. Deeper in the profile (70 cm) a gypsic horizon is common. The lacustrine origin of the marl soils is witnessed by the presence of numerous shells and shell fragments.

Lr Ridge soils. The ridge soils are deep and dark-grayish-brown with a texture ranging from sandy-loam to sand. As a rule they lack any structure though weak subangular elements may be found in loamy layers. In all profiles gravel of different sizes is present. The subsoil often contains shells of various sizes, mainly *Dreissenia*. Biological activity is poor; rodent (*Citellus*) influences dominate. Lime segregation is common; gypsum is only locally found (below 180 cm) as veins or as big clusters.

Lp Sandplain soils. The sandplain soils range from brown (surface soil) to light-brownish-gray and in texture from loamy-sand to loam. They usually lack any structure although in the heavier textured parts prismatic elements are sometimes present. Locally sandplain soils are very rich in calcium carbonate. A calcic horizon often occurs at 70 to 100 cm with a carbonate content up to 35%. This carbonate occurs as concretions or as distinct white soft spots.

Miscellaneous land types. The soils of the miscellaneous land types are too unimportant to be subdivided on a semidetained level. It suffices here to mention only the six land types that have been mapped: limestone uplands, colluvial slopes, creek bottoms, marshes, hüyük (ancient dwelling sites) and cobbly gullies.

Their soils are hardly suited for any form of arable farming. Partly these lands do not have any soil at all, and where it is present the areas are very small and of a poor quality due to stoniness, shallowness of profile, slope, wetness or salinity.

The hüyük are by far the best of the mentioned land types. They are man-made and partly used for agriculture.

Salinity and alkalinity

Saline and alkaline soils occur in the lower parts of the area but not in the terraces, bajadas and the higher parts of the alluvial fans, nor on the ridges and higher sandplains.

Salinity in the Çumra Area is mainly caused by inadequate drainage in the present irrigation system. Water applied in the higher parts seeps towards the northern low-lying sediments where it slowly evaporates, thus causing accumulation of salt.

Although, strictly speaking, alkalinity is not governed by salinity, non-saline alkali soils do not or only rarely occur. This is probably due to the high gypsum content of many of the soils.

Soil suitability

The soils of the Çumra Area have been placed in eight suitability classes. The division is based on crop yields, hydrological data and profile characteristics as observed in the field and in the laboratory. More than half the Çumra Area consists of

good to very good soils. Of this 50% is irrigated. Some 30% of the area is occupied by soils with severe or very severe limitations for arable cultivation; mainly they are waterlogged or saline. The remaining 20% is not at all suitable for agriculture, because of their poor mineral composition, besides wetness and salinity.

Appendix: Soils of the Çumra Experimental Station

The soils of the Çumra Experimental Station include clayey Çarşamba deposits mainly. Small patches of loamy and sandy soils occur. A cross section was made to study differences in the soil caused by a former river channel, which traverses the area. A soil map on scale 1 : 11,000 was compiled as well as a map showing the occurrence of lime segregation, rust-mottling, shells and gravel. A study was made of the station's unique irrigation system and its effect on soil salinity.

Özet

Çumra alanı, Orta Anadolu'da büyük Konya düzlüğünde Çumra Köyünün yakınında yer alır. Bu alan tahminen 100.000 hektarı kaplar. 1964-1966 senesinin tarla mevsimleri süresince bu alanın yarı mufassal toprak haritası, bir araştırma ve eğitim programı çevresinde projeyi himaye eden Wageningen (Hollanda) Ziraat Üniversitesi Toprak İlimi Kürsüsü Tropik topraklar profesörü Dr. P. Buringh'in liderliği, Mr. T. de Meester'in (1964-1965) ve Mr. P. M. Driessen'in idaresinde 10 Türk ve Hollandalı mezun talebelerle yapılmıştır. Etüd için, Türk Hükümeti tarafından temin edilen hava fotoğrafları ve topoğrafik haritalardan istifade edilmiştir. Neticede 1 : 100.000 lik bir toprak haritası elde edilmiştir.

Çumra arazisi nisbeten soğuk kıştan sonra, sıcak ve belirli yazı ile yarı kurak iklime sahiptir.

Kuzey batı ve güney batı köşelerindeki bazı alçak ve kısmen bataklık alan ve koyun ve sığır otlatmasında kullanılan kısım istisna edilirse geri kalan alan pulluk altındadır.

Fizyografi bakımından, 10 büyük arazi parçası tefrik edilmiştir; daha az önemde olan 6 arazi parçası ise 'Diğer Arazi Tipleri' adı altında bir kategori içine alınmıştır.

Topraklar için aşağıdaki altbölümler yapılmıştır.

Topraklar

Te Düz Teras Toprakları. Genel olarak düz teras toprakları derin ve tınlı, renkleri kahverengiden koyu kahverengine, çok açık kahverengine, profilin daha derinlerinde sarımsı renkler arasında değişmektedir. İyi gelişmiş B horizonu ile aynı şekilde 40 ve 80 cm arasında toz paketler ve sert konkresyonlu bir kalsik horizonları vardır. 130 cm. den daha derinde ekseriya ya sert danecikler yahut küçük beyaz kristalleri havi bir gipsik horizon mevcuttur.

Bu toprakların hemen hepsi sert ve yumuşak kireç parçacıklarını havi çok kireçli bir alttoprağa sahiptir.

Th Dalgalı Teras Toprakları. Dalgalı teras toprakları daha ziyade sathi veya çok sathi ve 20 ile 30 cm. arasında belirli bir kalsik horizonuna sahip olup içinde köşeli taşlar bulunur. Profil erozyonla kesilmiş olabilir. Bu toprakların bir kısım kuru ziraat altındadır.

Tg Teras Yarıntısı Toprakları. Teras yarıntısı toprakları, taban toprakları ile yarıntı yamaçlarındaki topraklardan ibarettirler. Bunların derinlikleri değişir ve profil gelişmesi ya hiç yoktur veyahut zayıf gelişmiştir. Yarıntı tabanları taşlı ve çok karı-

şıktır. Yarıntı yamaçları sığ olup yer yer kalker aflörmanları göze çarpar.

Ar Bajada Toprakları. Bajada toprakları genel olarak derin olup sarımtrak bir solum üzerinde kahverengimsi killi bir üst toprak ihtiva ederler. 30-40 cm den başlayıp 60 cm veya daha kalın iyi gelişmiş bir B horizonu vardır. Daha derinlerde pek çok Slickensides- kaygan yüzeyler bulunur. Alt topraklarda kireç artar. Eğer bajada teras toprak üzerine yığılmışsa, mevzii olarak karbonatlı alt toprak mevcuttur.

Am May Nehri Birikinti Yelpazesini Toprakları. May nehri toprakları genel olarak derin, tekstür bakımından kaba kum ve çakıldan, tın ve kile kadar değişen, yer yer tabakalı bir alt toprak mevcuttur. Bunlar yeknesak olarak kahverengiden grimsi kahverengi yahut koyu kahverengine kadar değişip, zayıf yahut orta yuvarlak köşeli bloklu strüktüre sahiptirler. Bununla beraber yer yer Ap ve C horizonlarında bloklu ve prizmatik strüktür bile göze çarpar.

Killi ve tınlı topraklarda 'Kil topları' (yuvarlak, 1 cm çapında kadar ağır tekstürlü elementler) yaygındır. Kireç toplanmalarına 50 ile 80 cm derinliklerine rastlanır.

Ac Çarşamba Nehir Birikinti Yelpazesini Toprakları. Çarşamba nehrinin toprakları orta derin veya derin olup renk bakımından yeknesak olarak kahverenginden koyu kahverengine kadar değişirler. Bunlar daha ziyade killi yahut tınlı, dırlar. Köşeli bloklu ve prizmatik strüktür yaygın olup, alt toprakta ykanarak gelmiş kil kütanları mevcuttur. Her ne kadar bütün topraklar kireç ihtiva ederlerse de hakiki bir kalsik horizon teşekkül etmemiştir. Önceki kök kanalları, canlıların meydana getirdiği boşluklar, küçük ve iri gözenekler profili çok gözenekli yapmışlardır. Çok mevzii olarak kumlu alt toprak ve hatta tamamen kumlu profiller bulunur.

Ab Eski Bataklık Ardi Toprakları. Eski bataklık ardi toprakları derin olup tekstürleri ağır kilden tına kadar değişir. Renkleri koyu sarımsı kahverengi ve kahverenginden açık kahverengimsi gri ve koyu griye kadar değişme gösterir: Hatta bazan hemen hemen siyah renkler bulunur. Bu topraklar şişer ve büzülürler, kendi kendine karışan bir yüzey tabakası vardır. Köşeli strüktür elemanların'a havi A horizonunun altında, kuvvetli iri bloklu ve prizmatik yapılı belirli strüktürel bir B horizonu mevcuttur. Alt toprakta kolayca görülen kaygan yüzeyler bulunur. Yer yer yüzey toprağın çatlaklardan düşerek alt toprağa karıştığı görülür. Sekonder kireç oluşumu zayıftır; yalnız bir kaç zayıf konkresyon yahut küçük beyaz lekeler bulunur. Ekseriya jips damarları, lekeleri ve grupları mevcuttur. Yer yer alt toprakta Dreissensia ve Planorbis'lerin kabukları bulunur.

Lc Yumuşak Kireç Toprakları. Yumuşak kireç toprakları % 90 gibi yüksek bir karbonat miktarına sahip olabilirler. Genellikle, bunlar grimsi kahverengiden koyu kahverengine, tınlıdan killiye kadar değişen çok kireçli ince bir A horizonuna sahiptirler. Yer yer yumuşak beyaz kireç bu düzlüğü yelpaze şeklinde örten sığ gölardı tortuları tarafından kaplanmıştır. Her ne kadar bazan B horizonu bulunursa da, ekseriyetle A doğrudan doğruy her hangi bir değişikliğe ugramamış olan yumuşak kireç ana maddesi üzerinde bulunur. Ana madde sertleşmiş halde olabilir. Bazı profiller alt toprakta kumlu veyahut siltli materyale sahiptirler. Yüzey toprağının tekstürüne bağlı olarak strüktür zayıf yuvarlak köşeli bloklardan kuvvetli iri prizmatik yapıya kadar değişir. Alt toprak ise daima massif ve yapısızdır. Hem sekonder kireç

(Kalsik horizon) ve hem de jips toplanmaları mevcuttur. Yer yer alt toprakda neojen orijinli sert kalkerler bulunur.

Lm Marn Toprakları. Marn toprakları derin ve siltli, yahut kireçli siltli killi tından ibaret tirler. Yer yer, ince kum katlarını ihtiva ederler. Bunların renkleri koyu grimsi kahverenginden solgun zeytuni ve beyaza kadar değişir. Genellikle bunlar zayıf pul strüktürlü bir A horizonu ve küçük, orta yuvarlak köşeli bloklu yapıli bir B horizonuna sahiptirler. B horizonunda, prizmatik ve köşeli bloklu strüktüre de rastlanır. Alt toprağın yapısı ise prizmatik ve küçük köşeli bloklu elemanlardan ibarettir. Toprakların ortalama kireç miktarı % 50 olup yumuşak kireçli topraklardaki kireç miktarından çok azdır. Ekseriyetle beyaz kireç paketlerini, konkresyonlarını ve lekelerini gösteren bir kalsik horizon mevcuttur. Profilin derinlerinde (70 cm.) bir jips horizonu yaygındır. Marn toprakların lakustrin (göl yataklarında oluşun) orijinli oldukları sayısız fosil ve fosil parçacıklarının varlığından bellidir.

Lr Kum bendi Toprakları. Kum bendi toprakları derin ve kumlu tından kuma kadar değişen tekstürde koyu grimsi kahverengi topraklardır. Kaide olarak strüktürsüz olmakla beraber tınlı tabakalarda zayıf yuvarlak köşeli elemanlar bulunabilir. Bütün profillerde farklı büyüklükte çakıllar bulunur. Alt toprakda çeşitli büyüklüklerde bilhassa Dreissensia kabukları bulunur. Biyolojik faalliyet zayıftır. Rodent (Citellus) etikisi esastır. Kireç yığışmaları yaygındır. Jips ise yer yer damarlar ve gruplar halinde (180 cm den derin) bulunur.

Lp Kum Düzükleri Toprakları. Kum düzlükleri toprakları kahverengiden (üst toprak) açık kahverengimsi griye, tekstür bakımından tınlı kumdan tına kadar değişirler. Bunlarda strüktür yoksa da ağır tekstürlü kısımlarda bazan prizmatik elemanlar bulunur. Bütün kum düzlüklerinin toprakları kireççe zengindir. Ekseriya % 35'e kadar kireç ihtiva eden, 70 ile 100 cm derinlikte bir kalsik horizon bulunur. Bu kireç ya konkresyonlar yahut belirli yumuşak beyaz lekeler halindedir.

Diğer Arazi Tipleri. Diğer arazi tipleri yarı-mufassal toprak sınıflandırmasında alt kısımlarına ayrılmayacak kadar önemsizdir. Burada yalnız altı arazi tipinin haritalandığından bahsetmekle iktifa edilecektir. Kalker Dağları, Kolluviyal Meyiller. Çay Tabanları, Bataklıklar, Höyükler (Eski yerleşme yığıntıları) ve Taşlı Yarıntılar.

Bunların toprakları herhangi bir toprak işlemesine kolaylıkla müsait değildir. Bu arazilerin bir kısmında zaten toprak yoktur; olan yerlerde ise ya arazi çok küçüktür veyahut taşlılıktan, profilin are olmasından, meyilden, ıslaklıktan veya tuzluluktan dolayı düşük evsaftadırlar.

Höyükler bu arazi tiplerinin en iyisidir. Bunlar insan tarafından yapılmış olup, kısmen ziraatte kullanılmaktadır.

Tuzluluk ve Alkalilik

Tuzluluk ve alkalilik arazinin yalnız alçak kısımlarında bulunur. Bajada'lar aluviyal nehir yelpazelerinin yüksek kısımlarında, kum bendi topraklarında ve yüksek kum düzlüklerinde tuzluluk ve alkalilik yoktur.

Çumra arazisindeki tuzluluk daha ziyade mevcut sulama sisteminin yetersiz drenaj kapasitesinden meydana gelmiştir. Yukarı kısımlarda tatbik edilen su, yavaş yavaş buharlaştığı kuzeydeki daha alçak sedimanlara sızıp tuzların yığılmasına sebep olmaktadır. Her ne kadar tam anlamıyla alkalilik tuzluluğa bağlanamazsa da, tuzsuz alkali topraklar ya hiç veyahut nadiren bulunur. Bu belki de toprakları çoğunun yüksek jips ihtiva etmelerinden ileri gelir.

Toprak Kullanma Kabiliyeti

Çumra havalisi toprakları sekiz kullanışlılık sınıfına ayrılmıştır. Bu şekilde ayırma, bitki verimi, hidrolojik ve, arazi ve laboratuvarında elde edilen profil karakteristiklerine dayanmaktadır.

Çumra arazisinin yarısı veya daha fazlasının iyi yahut çok iyi topraklar olduğu görülmektedir. Bu arazinin % 50 si sulanmaktadır. Arazinin % 30'u toprak işlenmesi için ciddi veya çok ciddi nazurları olan topraklar tarafından kaplanmıştır. Bunlar daha ziyade su altında kalmış yajut tuzlu topraklardır. Geriye kalan % 20, zayıf mineral yapılışı (ıslaklık ve tuzluluktan başka) dolayısıyla ziraate hiç elverişli değildir.

Ek: Çumra İstasyonu Toprakları

Deneme istasyonunun toprakları esas intibariyle killi Çarşamba nehir birikintilerini içine alır. Küçük parçalar halinde tınle ve kumlu topraklar da mevcuttur. Sahanın bir yanından öbür yanına geçen eski nehir yatağının etkisi altına aldığı topraklardaki değişiklikleri görmek için, bir kesit yapılmıştır. Sahanın, 1/11.000 lik toprak haritası ve mümkün olabildiği doğrulukta, kireç birikintileri, pas lekeleri, fosil parçacıkları ve çakılları gösteren başka bir haritası meydana getirilmiştir. İstasyonun yegane sulama sisteminin toprak tuzluluğuna etkisi üzerinde de ayrıca bir çalışma yapılmıştır.

Appendix: Soils of the Çumra Experimental Station

Introduction

During the second half of August 1964 the 80 hectares of the 'Çumra Experimental Station for Irrigated Agriculture' were mapped in detail by Driessen. Some 250 observation points were studied (auger holes down to 120 cm) as well as a number of pits, dug in some of the most important soil units. A cross section was made to trace layers deviating in texture and permeability.

Some soil samples were transported to the Netherlands to be analysed in the salinity laboratory of the Department for Soils and Fertilizers of the Agricultural University of Wageningen. In addition to the soil map a sketch map presenting the occurrence of gravel, rust, lime mottling and shells was compiled.

The Experimental Station (fig. 37) is located east of the Village of Çumra at 1013 m altitude. The area is almost flat and completely irrigated. The main crops grown are: wheat, melons, grapes, sugar-beet and alfalfa as well as vegetables, fruit and poplar trees.

The Station is located on the recent alluvial clayey and loamy river deposits of the River Çarşamba. The station has a unique irrigation system. The same irrigation water is repeatedly supplied to the crop and is only gradually removed. This means a considerable increase of the quantity of irrigation water ultimately available, but it contributes to the salinity prevailing locally on the station's territory.

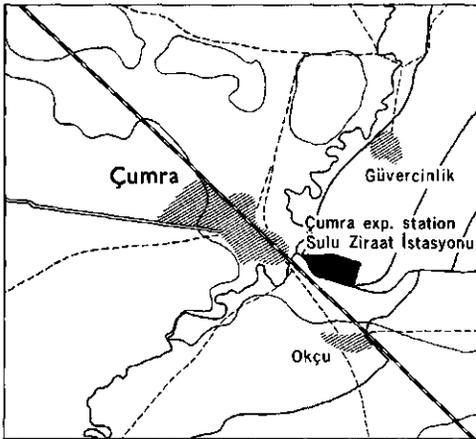
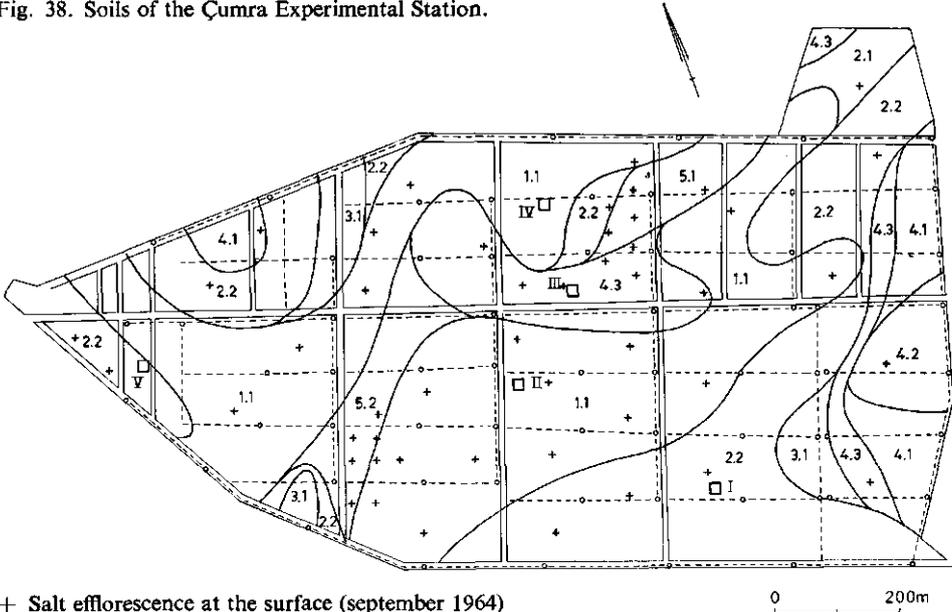


Fig. 37. Location of the Çumra Experimental station.

Şekil 37. Çumra Deneme İstasyonu'nun mevkii haritası.

Fig. 38. Soils of the Çumra Experimental Station.



- + Salt efflorescence at the surface (september 1964)
Toprak sathında tuz kristalleri (Eylül 1964)
- Soil pit
Boy çukuru

0 200m

1 Çumra clay	Çumra kili
1.1 Çumra clay	Çumra kili
2 Çumra clay and clay-loam over loam	Çumra kili ve kili tını, tın üstünde
2.1 Çumra clay and clay-loam over loam deeper than 20 cm	Çumra kili ve kili tını, tın üstünde, 20 cm den daha derin
2.2 Çumra clay and clay-loam over loam deeper than 40 cm	Çumra kili ve kili tını, tın üstünde, 40 cm den daha derin
3 Çumra clay-loam	Çumra kili tını
3.1 Çumra clay-loam grading into clay	Çumra kili tını, sonra kil
4 Çumra loam	Çumra tını
4.1 Çumra loam	Çumra tını
4.2 Çumra loam, imperfectly drained phase	Çumra tını, oldukça fena drenaj fazı
4.3 Çumra loam on clay or clay-loam between 20 and 80 cm	Çumra tını, 20-80 cm arasında kil veya kili tını üstünde
5 Complex soils	Komplex toprak
5.1 Complex of 1 and 3.1, gravel between 40 and 80 cm	1 ve 3.1 ün kompleksi ve 40-80 cm arasında çakıllı
5.2 Complex of 1 and 3.1, without gravel	1 ve 3.1 ün kompleksi, çakılsız

Şekil 38. Çumra Deneme İstasyonu'nun toprak haritası.

The soils of the Çumra Experimental Station

The soils distinguished are Çumra clayey and Çumra loamy soils. They take part of soil series Ac 1.1. Predominantly clay and clay-loam occur. For a general description of this series reference is made to chapter 4.2.3 of the report.

The Çumra clayey soils have been subdivided into 4 map units:

- 1.1 Çumra clay
- 1.2 Çumra clay and clay-loam over loam between 20 and 40 cm
- 1.3 Çumra clay and clay-loam over loam deeper than 40 cm
- 1.4 Çumra clay-loam grading into clay

The Çumra loamy soils include 3 map units:

- 2.1 Çumra loam
- 2.2 Çumra loam, imperfectly drained phase
- 2.3 Çumra loam over clayey material between 20 and 80 cm.

In addition 2 complex units were distinguished, viz.:

- 3.1 Complex of 1.1 and 1.4 with gravel between 40 and 80 cm
- 3.2 Do, without gravel.

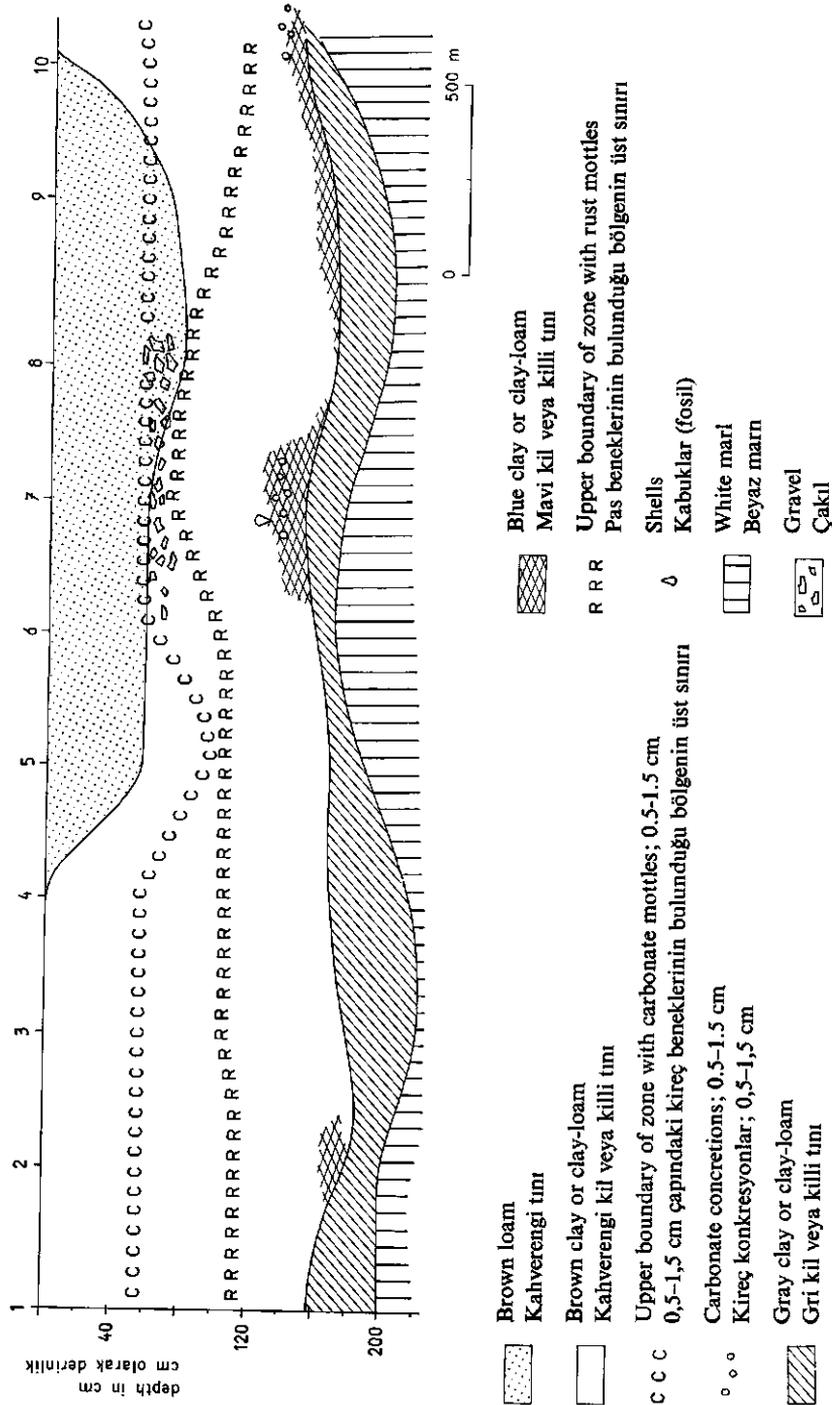
The Çumra clayey soils mapped here often become coarser between 20 and 40 cm. Pit No 20, described in chapter 4.2.3, is an example of such a clay or clay-loam over loam. Clay-loam grading into clay also occurs but is less common than clay-loam subsoil. The Çumra loamy soils occur in the eastern part of the station. There an imperfectly drained phase was distinguished (mapping unit 2.2) coinciding with a former pond filled up by man. Imperfect drainage also occurred in other profiles in these loams, e.g. in the centre of the area where a gully-shaped complex of clay and loam over clay was mapped. This complex (clearly visible at the aerial photograph) represents an ancient river branch. The presence of gravel, coarse sand and shell fragments support this assumption.

The major part of the station's territory consists of deep brown Çumra clay and clay over clay-loam. The described pits No II and IV, presented in the next paragraph are representative for Çumra clay soils; Çumra clay over clay-loam is described in Profile No I. The former river branch mentioned consists of a complex of deep-brown clay, clay-loam and loam over clay. Locally the change in texture is hard to trace and in general this unit differs only slightly from Çumra clay (mapping unit 1.1).

At the eastern and north-eastern side of the station loamy soils occur, locally becoming gray between 80 and 120 cm (imperfectly drained phase).

Of part of the northern half of the station a cross section was made to study the difference in the soil as caused by the former river branch to trace the depth and nature of the carbonatic subsoil. A sketch of this cross section is given in figure 39. This figure shows that the soft lime subsoil is present at depths of appr. 2 m below land surface. The presence of an ancient river branch is reflected in the occurrence of gravel, lime segregation, shell fragments, blue (reduced) clay and a considerably higher level of rust mottling in the profile. Between the white lime and the overlying brown clay

Fig. 39. Cross-section of part of the Çumra Experimental Station. The exact location of this cross-section is indicated in fig. 40.

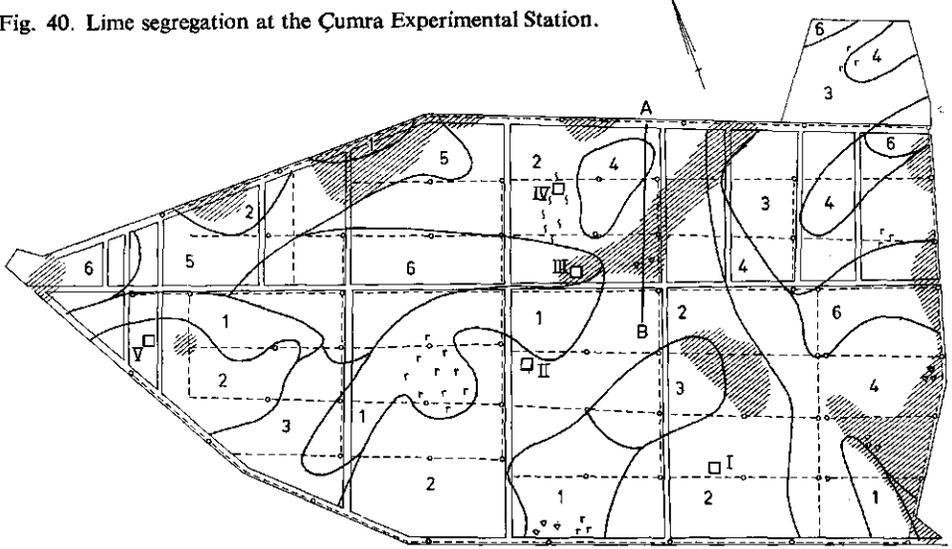


Şekil 39. Çumra Deneme İstasyonu'nun bir parçasının kesiti. Bu kesitin egas yeri toprak haritasında gösterilmiştir.

and loam a transition zone with grayish colours exists.

In the northern half of the river branch a pit was dug. Its profile is described as Profile No III. Since at this site groundwater is very high it was not possible to establish the exact thickness of the gravel layer present there.

Fig. 40. Lime segregation at the Çumra Experimental Station.



- ''' Rust mottling
- ''' Pas benekleri
- ''' Shell fragments between 40 and 80 cm
- ''' Fosil kabuk fragmanları 40 ve 80 cm arasında
- ''' Lime between 80 and 120 cm
- ''' 80 ve 120 cm arasında çok kireç
- ''' Gravel between 40 and 80 cm
- ''' 40 ve 80 cm arasında çakıl
- Cross-section
- A-B Kesit
- Soil pit
- Boy çukuru

- 1 Carbonate mottles beginning between 0 and 40 cm, down to 120 cm
- 2 Carbonate mottles beginning between 40 and 80 cm, down to 120 cm
- 3 Carbonate mottles beginning between 80 and 120 cm, down to 120 cm
- 4 Carbonate mottles between 40 and 80 cm
- 5 Carbonate mottles at different depths, mostly between 30 and 100 cm, and not only between 40 and 80 cm
- 6 No carbonate mottles

- 1 Kireç lekeleri 0 ve 40 cm arasında başlar, 120 cm yekadar devam eder
- 2 Kireç lekeleri 40 ve 80 cm arasında başlar, 120 cm yekadar devam eder
- 3 Kireç lekeleri 80 ve 120 cm arasında başlar, 120 cm yekadar devam eder
- 4 Kireç lekeleri 40 ve 80 cm arasında
- 5 Kireç lekeleri profil değişti derinlikte daha çok 80 ve 100 cm arasında yalnız 40 ve 80 cm arasında yoktur
- 6 Kireç lekeleri yoktur

Şekil 40. Çumra Deneme İstasyonu'nun farklı kısımlara bölünmüş kireç haritası.

Next to the soil map a single value map was compiled presenting the occurrence of gravel, lime and rust mottling, shells, etc. (see figure 40). By far the largest part of the soils at the station have lime segregation as powdery mottling or as pseudomycelium. Incidentally concretions were found in very small quantities. The lime mottles are uniformly sized with a diameter between 3 and 10 cm. They occupy not more than 20% of the profile's surface except for one observation point where pseudomycelium was found in considerable quantities. Shell fragments occur at several places. Due to their small size they could not be identified. As the surface of the fragments was comparably smooth and without clear curves *Dreissenia* spp. is thought most probable. Gravel occurs spotwise, mainly along northern and eastern borders of the station and at one or two observation points in the centre. Rust mottling commonly occurs between 80 and 120 cm and does not exceed 5% of the profile.

Summarizing only small parts of the station have a soil profile that is very different from the Çumra clay as defined in 4.2.3. These areas are not used for experimental purposes; the loam in the eastern part is used as pasture land and for alfalfa growing, the loamy part in the north-west is used as a nursery for fruit trees. The rest of the station mainly consists of Çumra clay or clay over heavy clay or clay-loam. As the soil boundaries are very gradual only slight differences occur in the small experimental fields. The ancient river branch in the middle of the station influences plant growth considerably. At that place the crops are locally of poor quality.

Profile descriptions

The descriptions mentioned above are produced here. For their location reference is made to the soil map. As the most important general data are valid for all the profiles they will be given only once:

General data

Profile number: resp. I, II, III and IV.

Location: see soil map

Date of description: second half of August 1964.

Described by: Ir P. M. Driessen.

Soil site characteristics

Geology: River Çarşamba deposit, clayey and loamy soils

Physiography: alluvial plain

Relief: flat

Slope: level

Stoniness: Class 0

Hydrology: well drained, if irrigated groundwater may be as high as -40 cm

Moisture: moist

Salinity: non or slightly saline

Biological activity: well rooted; many wormholes, few rodent activity; profile well homogenized

Vegetation: several crops, mainly for experimental purposes

Land-use: experimental fields and cash crops

Classification 7th Appr.: 1964 Calciorthid or Camborthisd

1967 Calciorthid or Camborthisd depending on the presence of a calcic horizon

Profile No I

- Ap** 0– 23 cm pale-brown (10YR 6/3) to brown (10YR 5/3) clay to clay-loam; medium to strong prismatic structure; slightly sticky and slightly plastic when wet, firm when moist and hard to very hard when dry; large cracks (1 cm); few wormholes of different diameter; common mesopores and macropores; common small roots; lower boundary clear and wavy.
- B 1** 23– 40 cm brown (10YR 5/3) clay to clay-loam; weak fine-angular-blocky structure; slightly sticky and slightly plastic when wet, firm when moist and hard to very hard when dry; common mesopores and macropores; common fine (3 mm) cracks; common fine roots; lower boundary clear and irregular to broken.
- B 21ca** 40– 55 cm brown (10YR 5/3) clay-loam to loam; weak fine-angular-blocky structure; sticky and slightly plastic when wet, very friable when moist; common mesopores and macropores; common lime mottles and common loamy pockets; lower boundary gradual to diffuse and smooth.
- B 22ca** 55–120 cm brown (10YR 5/3) clay-loam to loam; weak fine-subangular-blocky structure; slightly sticky and slightly plastic when wet and very friable when moist; common mesopores and many macropores; common distinct fine lime mottles; some coloured sand.

This profile processes and ochric epipedon and a cambic and calcic horizon.

Profile No II

- Ap** 0– 22 cm brown (10YR 5/3) clay to clay-loam; moderate coarse-prismatic and angular-blocky structure; slightly sticky and slightly plastic when wet, friable when moist and hard to very hard when dry; common fine and medium cracks in the structure elements; many mesopores and common macropores; common fine and few large roots; lower boundary clear and wavy.
- B 1ca** 22– 57 cm brown (10YR 5/3) clay to clay-loam; moderate to weak fine-angular-blocky structure; slightly sticky and slightly plastic when wet, very friable when moist and hard to very hard when dry; few fine cracks in and between the structure elements; few mesopores and common macropores; some fine, coloured sand; very few medium lime spots; few fine and medium roots; lower boundary clear and irregular to broken.
- B 2ca** 57– 90 cm brown to dark-brown (7.5YR 4/4) clay to clay-loam; weak fine-angular-blocky structure; slightly sticky and slightly plastic when wet, very friable when moist and hard to very hard when dry; few mesopores and common macropores; few lime mottling and few fine and medium roots.

This profile possesses and ochric epipedon and a cambic and calcic horizon.

Profile No III

- Ap** 0– 18 cm brown to dark-brown (10YR 4/3) clay-loam to loam; weak fine-angular-blocky structure; slightly sticky and slightly plastic when wet, very friable when moist and hard to very hard when dry; many mesopores and common macropores; few fine roots and some coloured sand; lower boundary clear and smooth to wavy.
- B 2** 18– 72 cm brown to dark-brown (10YR 4/3) silt-loam with a weak fine-subangular-blocky structure; sticky and slightly plastic when wet, very friable when moist and hard when dry; few wormholes and many mesopores and macropores; few roots; lower boundary clear and smooth.
Groundwater level at –62 cm.
- IIC** > 72 cm Coloured gravel (3–10 mm).

This profile possesses an ochric epipedon and a cambic horizon.

Profile No IV

- A 1 0- 45 cm (No plough layer could be distinguished) brown to dark-brown (10YR 4/3) clay; moderate fine-angular-blocky structure; slightly sticky and slightly plastic when wet, very friable when moist and hard to very hard when dry; many mesopores and macropores; common fine roots (0.8 mm); common fine cracks; some coloured fine sand; lower boundary gradual and wavy.
- B 2 45- 92 cm brown to dark-brown (10YR 4/3) clay; distinct to moderate very fine-angular-blocky structure slightly sticky and slightly plastic when wet and very friable when moist; common fine roots and few lime mottles (10 mm); common mesopores and macropores.

This profile possesses an ochric epipedon and a cambic horizon.

Salinity at the Çumra Experimental Station

Salt efflorescence was locally recorded at the end of the dry summer season. This is partly due to the irrigation system applied but the main reason for these symptoms is found in inadequate drainage of the experimental fields. The irrigation system of the station is such, that irrigation water supplied by the near River Çarşamba is applied several times, which means that leached out soluble salts are carried back to the fields. Unless the drainage system is perfect this method induces a relatively high salt content. Because of the good quality of the Çarşamba water (EC = 0.4 mmho/cm) an actual increase of the conductivity up to 1 mmho/cm is not serious. However this value qualifies the salt content (according to USDA Handbook 60) as 'high'. The possibilities for application of this 'high-salinity-water' are defined as follows: 'Cannot be used on soils with restricted drainage. Even with adequate drainage special managements for soil salinity control may be required and plants with good salt tolerance should be selected'. Nevertheless water in the range of 0.75 to 2.25 mmho/cm is often applied with good results, but if leaching and drainage are inadequate (as they are more or less at the station) saline conditions will quickly develop. The drainage system consists of tile drains (American type, diameter 10 cm) with 100 m intervals between the lines. This systems capacity is not high enough to drain the irrigation gifts and the (presumably considerable) seepage from the main canal south of the station adequately. Additional measures are necessary here.

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