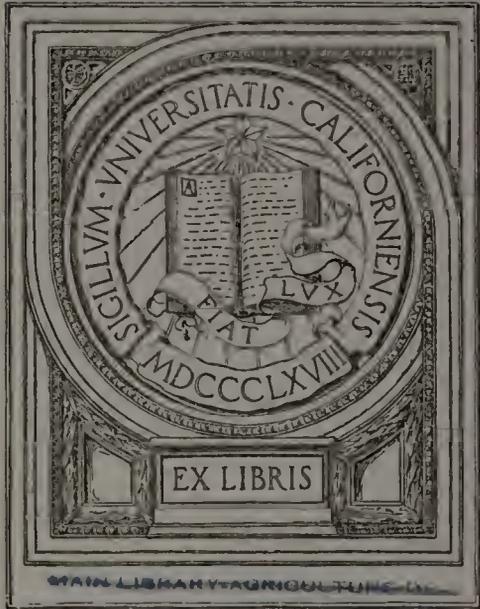


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Technical and Scientific Service.

—Bulletin No. 21.—

REPORT ON A SOIL  
SURVEY OF ZONE  
No. 1 (GHARBÎYA),  
1921,

By FRANK HUGHES.

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## EXPLANATORY NOTE.

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At the suggestion of the Director-General of the State Domains Administration, the Chairman of the Land Reclamation and Disposals Board (Mr. J. Langley) asked the Chemical Section of the Ministry of Agriculture to make an examination of the soil of the area known as Zone No. 1, Gharbíya. With the assistance of A. Wood Bey and Mr. O'Keefe of the Land Reclamation Service of the State Domains, a scheme was prepared and sampling was commenced as soon as the land was sufficiently dried after the winter flooding (1920-1921).

My thanks are due to the Chairman of the Land Reclamation and Disposals Board (Mr. A. McKillop), and to the Director-General of the State Domains Administration for permission to publish this Report, to A. Wood Bey and the staff of the Reclamation Service of the State Domains for the collection of the samples, and to Mr. R. Aladjem and Ali Ragheb Eff. who have made the large number of chemical and mechanical analyses involved.



# MINISTRY OF AGRICULTURE, EGYPT.

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## Bulletin No. 21.

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### REPORT ON A SOIL SURVEY OF ZONE No. 1 (GHARBIYA), 1921.

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During the early part of 1921 a preliminary soil survey was made of an extensive tract of Government land in Gharbiya (Zone No. 1). The area in question, 126 square kilometres (30,000 feddâns, approx.), lies between Fariskûr and Kafr el Wastâni and is bounded on the north by the Kafr el Battikh Drain. A map was made of the area.\* this was then divided into kilometre squares by lines running N-S and E-W; at the points of intersection of a N-S line with an E-W line a bore was made and samples of the soil taken at the surface and at depths of one, two, and three metres. By distinguishing the E-W lines by letters and the N-S lines by numbers the location of any bore could be easily indicated. As the number of samples collected amounted to about 500 it was evident that anything approaching a complete analysis of each sample was out of the question, nor is it likely that such a proceeding would yield results of any great practical value. It was therefore decided to estimate in each sample the Total Soluble Salts and Chlorine (expressing the latter in the form of Sodium Chloride, the condition in which most of the chlorine in a soil usually occurs), to test each sample for Sodium Carbonate and to make a simple mechanical analysis. This would enable one to locate any beds of soil in any way different from the main bulk. The amount of carbonate of lime was also determined in samples taken at sixteen selected points evenly distributed over the whole area examined.

The bores were made with an auger, but to ensure that the sample was drawn from the desired depth a special instrument was constructed. This consisted of a short length of steel tubing attached to an iron rod. When a hole had been bored with the auger to nearly the required depth the auger was removed and the bore hole made as clear as possible. The tube, which was of a less diameter than the auger, was then lowered in the bore and pressed into the soil. In this way the tube could be partially filled with soil at any desired depth. This

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\* The map attached hereto (Scale 1 : 1,201,000) is similar but on a reduced scale.

method was suggested by A. Wood Bey, the Director of the Land Reclamation Section of the State Domains Administration. The arrangement worked quite well in this particular instance where the soil was damp and of a heavy nature. It would probably not answer in dry or sandy soils. In such cases it would be difficult to obtain a satisfactory bore, and it is possible that the tube would not retain the sample long enough to allow of its being brought to the surface.

The actual work of taking the samples was performed by members of the State Domains staff under the direction of Mr. C. F. O'Keefe. After partial drying the samples were despatched in batches of ten to twenty to the Chemical Laboratory for examination. On reaching the Laboratory the samples were further dried in the sun, the lumps being gradually reduced in size during the process of drying. This was continued until the soil was dry enough to be rubbed down with a wooden pestle. A small quantity was then dried at 100° C. and from this portions were taken for examination.

For the mechanical analysis 5 grammes of the soil were treated with 100 c.c. of a 0.1 per cent solution of sodium carbonate and boiled for fifteen minutes. This mixture was then transferred to a beaker of tall form and the level of the liquid brought to a height of ten centimetres by the addition of water. After thorough stirring the suspension was allowed to rest  $7\frac{1}{2}$  minutes, after which time the turbid liquid was poured off; this was thrice repeated, after which the residue was dried on the water bath, rubbed down with a soft camel hair brush and sedimented as before, repeating the process till the water was clear after standing  $7\frac{1}{2}$  minutes. The residue from which the **silt** and **clay** had thus been removed was washed upon a "100" sieve (*i.e.* a fine wire sieve the openings of which are approximately 0.01 inch square). The portion not passing the sieve was dried and weighed, this is the **coarse sand**. The portion passing the "100" sieve was also dried and weighed. This is the **fine sand**. These two weights were then calculated to percentages of the original sample. The percentage amount of soluble matter is added to the sum of the percentages of coarse and fine sand: this total, subtracted from 100, gives the percentage of silt and clay in the sample. Owing to the large number of samples it was impossible to separate the silt and clay, as this necessitates six or more sedimentations each of twenty-four hours' duration. For many purposes this is not of much practical importance, as in soils containing so large a proportion of clay, as most of the samples from this area showed, the presence of ten to twenty per cent more or less of silt would have but little effect upon the permeability of the soil.

It was at once noticed that the soils of this area contained very little carbonate of lime, and moreover the small amount present was

in an unusual form. Some may have been present in the form of fragments of marine or fresh water shell. By far the larger proportion was found in the coarser fractions as small grey agglomerations or concretions. This rather suggests that since the alluvium was deposited the carbonate of lime, occurring in fine particles, had been dissolved by the water of the overflow and had been redeposited in these small granules. These particles did not consist of pure carbonate of lime, but rather of a mixture of carbonate of lime, magnesia, and iron (ferrous); these accretions seldom exceeded a millimetre in diameter. It was not found practicable to collect a sufficiently pure material to make a quantitative examination, but qualitative tests showed them to possess the composition indicated above.

It was noted that over much of the area the samples from two and three metres depth exhibited an almost black appearance even when dry and in a fine state of division. This colour appears to be due to the presence of partially carbonized vegetable remains. Sulphide of iron could not be detected. Small fragments of vegetable debris were easily separated from this black subsoil. From the appearance of these under the microscope it seemed probable that this debris consisted largely of the fragmentary remains of rushes or similar marsh plants. The black soil showed traces of ferrous iron.

TABLE I.—AMOUNT OF CARBONATE OF LIME PRESENT IN THE SOIL AT 16 POINTS AT THE SURFACE AND AT DEPTHS OF ONE, TWO, AND THREE METRES.

Position.	Surface.	One Metre.	Two Metres.	Three Metres.
A 1	1.75	2.20	0.52	1.00
4	0.70	1.63	2.63	Trace.
7	0.75	1.59	2.88	2.84
10	0.63	2.15	1.27	1.81
D 1	0.79	2.00	3.00	1.11
4	1.09	1.04	2.50	0.72
7	1.00	0.48	3.39	2.70
G 2	1.13	0.66	Trace.	0.22
5	2.45	1.22	1.38	4.45
9	1.13	0.68	1.22	0.91
J 3	1.25	0.50	0.22	Trace.
6	1.00	1.09	0.82	0.82
9	2.13	2.00	2.18	2.32
M 1	5.00	0.52	0.93	1.13
3	1.77	2.15	1.43	1.09
P 2	1.97	2.38	1.04	1.93
Maximum ...	5.00	2.38	3.39	4.45
Minimum ...	0.63	0.48	0.22	0.22
Mean ... ..	1.53	1.39	1.56	1.44

The above figures are based upon determinations of carbonic acid and hence include all carbonates present in the soil.

In order to obtain some knowledge as to the condition in which the carbonate was present in the soil, the several fractions separated in the course of the mechanical analysis were examined. All the similar fractions obtained from each of six E-W rows of bores were mixed, each row separately. The carbonate was determined in each fraction, the results are shown in Table II.

TABLE II.

E-W Line.	A.	D.	G.	J.	M.	P.
Fraction ... ..	Carbonate of Lime, per cent.					
Coarse sand ... ..	2.7	4.7	7.4	7.5	13.6	14.5
Fine sand ... ..	1.1	1.3	0.8	0.9	0.8	1.0
Silt and clay ... ..	0.8	0.5	0.7	0.7	0.8	0.9

The above figures refer to mixtures of all samples taken on the E-W lines indicated, A being the most northerly (*see* Map). The large amount of carbonate in the coarse sand of the lines M and P is noteworthy. This deposit is probably the most ancient, but there is no evidence that there is any relation between the age of a deposit and the amount of carbonate. Moreover, on the average there is less carbonate in the deep than in the surface samples (*see* Table I). Much of this land is flooded yearly after the Nile flood, and only becomes dry in early summer. Whether there is any great accumulation of shells (of fresh water molluscs) during this inundation I am not aware, but it is quite possible that something of this nature might afford an explanation. Nile water contains a small amount of carbonate of lime in solution, and it is probable that molluscs, directly or indirectly, obtain the material for their shells from this source. This would explain the greater amount of carbonate in the southern portion which has been subjected to this annual flooding for a long period.

Nearly the whole of this area lies between the contours of 0.5 M and 1.0 M. There are a few small patches below the former and some higher than the latter, but their total area only represents a small proportion of the whole.

A summary of the results of the mechanical analysis is given in Table III.

TABLE III.—SHOWING AMOUNT OF FINE MATERIAL IN THE SOIL AT DIFFERENT DEPTHS ON EACH OF THE E-W LINES OF BORES.

Line.	Surface.	One Metre.	Two Metres.	Three Metres.	No.
A.	83.2	83.1	75.3	55.8	12
B.	77.8	87.0	77.2	60.2	15
C.	81.6	85.7	73.2	63.8	11
D.	74.0	86.3	80.9	67.7	9
E.	85.0	82.1	76.9	70.7	10
F.	81.3	79.5	75.1	71.1	13
G.	85.1	80.3	74.0	55.6	10
H.	75.5	72.7	67.3	66.6	11
I.	80.6	68.1	70.9	60.9	8
J.	71.7	61.9	73.7	78.1	8
K.	73.5	57.2	75.0	76.0	8
L.	81.1	51.8	75.5	77.6	7
M.	76.9	60.3	73.7	70.4	5
N.	76.3	59.9	65.3	60.9	6
O.	67.4	73.1	67.7	82.3	4
P.	54.7	68.1	79.0	65.6	3
Q.	85.3	81.9	87.8	73.3	2
R.	78.6	52.9	58.9	59.7	3
S.	87.7	62.3	65.9	83.1	1
Total number of samples examined ... .. 584					146

The last column shows the number of bores on each line (*see* Map).

The above figures represent the average for each E-W line. In ordinary Delta formation where the extension of land is produced by deposition of alluvium in sea water one would expect to find the finer material in the lower strata, since it is this material which would be carried farthest out to sea and would therefore be deposited in the deepest water. It may at first seem somewhat strange that in this area we have the coarser material at a depth of two to three metres covered in the majority of cases by a layer of nearly two metres of fine material. The explanation of this would appear to be somewhat as follows. At the present time much of this area is covered with water during flood and there is little doubt but that within comparatively recent times it must have formed a fresh water lake as is shown by the vegetable remains found in the black soil at a depth of two to three metres, *i.e.* below sea level. Before that time this lake probably communicated with the sea just as some of the Northern Lakes (Brullos, Menzala) do at the present time. If this communi-

cation became permanently closed by sand any considerable flow of fresh water during flood would be checked. This would prevent the fresh flood water from carrying coarse material into the lake, the water having insufficient velocity to transport any but the finer material, in this way the occurrence of fine material in the surface soil and much sand in the lower layers would be explained.

For purposes of comparison a few tests were made of four typical classes of soil found on this area, *viz.* :—

(1) Heavy surface soil, This covered the larger proportion of the total area.

(2) Light surface soil. Found in small patches only.

(3) Black subsoil at three metres depth. Fairly general at three metres.

(4) Sandy black subsoil at two to three metres. Met with in patches at two to three metres.

No. 1 swelled very considerably when wetted, permeable.

No. 2 proved to be very permeable.

No. 3 very slightly permeable. The water which passed through the soil was coloured.

No. 4 scarcely at all permeable. Percolate very strongly coloured.

Curves comparing the rates of percolation, under similar conditions through soils Nos. 2 and 4 show a most remarkable difference (Fig. 1). The mechanical analyses of these two soils are not very different, yet that from the surface is very permeable while the sandy soil from two to three metres behaves like a clay. From the fact that the percolate is coloured and deposits a flocculent precipitate of an organic nature on standing, it would seem that the impermeability is due to the presence of organic matter in a colloidal form.

The percolation tests were made as follows. Filter papers, very permeable, were fitted to Buchner funnels of 46 millimetres internal diameter; after wetting the papers, five grammes of the soil to be examined was spread as evenly as possible on the paper. The layer of soil was about two millimetres in thickness. The soil was now wetted carefully and the funnels filled with distilled water. The percolate was caught in graduated cylinders and the head of water in the funnels was maintained constant by means of a Mariotte's bottle suitably arranged.

The same marked difference is also shown in the rate at which water rises in these two soils by capillarity. A glass tube of 5 millimetres bore was loosely plugged at one end and filled with the fine dry soil, then gently tapped until the soil was compacted. The loosely plugged end of the tube was then immersed in water. The water at once commenced to rise in the soil as could be seen by the change in colour. Daily or more frequent readings were taken of the height to which the water had risen. These are shown in Figure 2.

Fig. 2

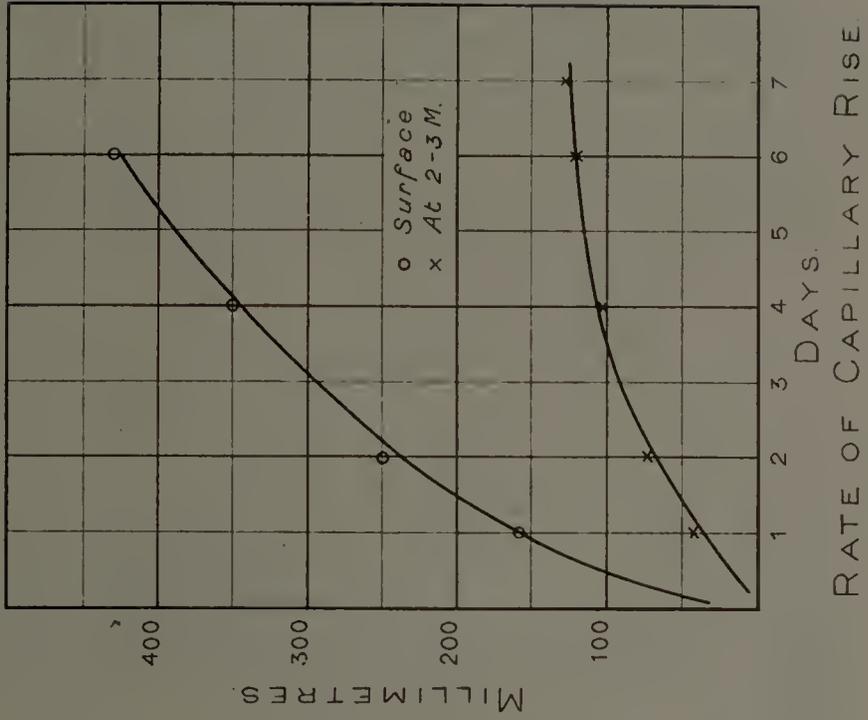


Fig. 1.

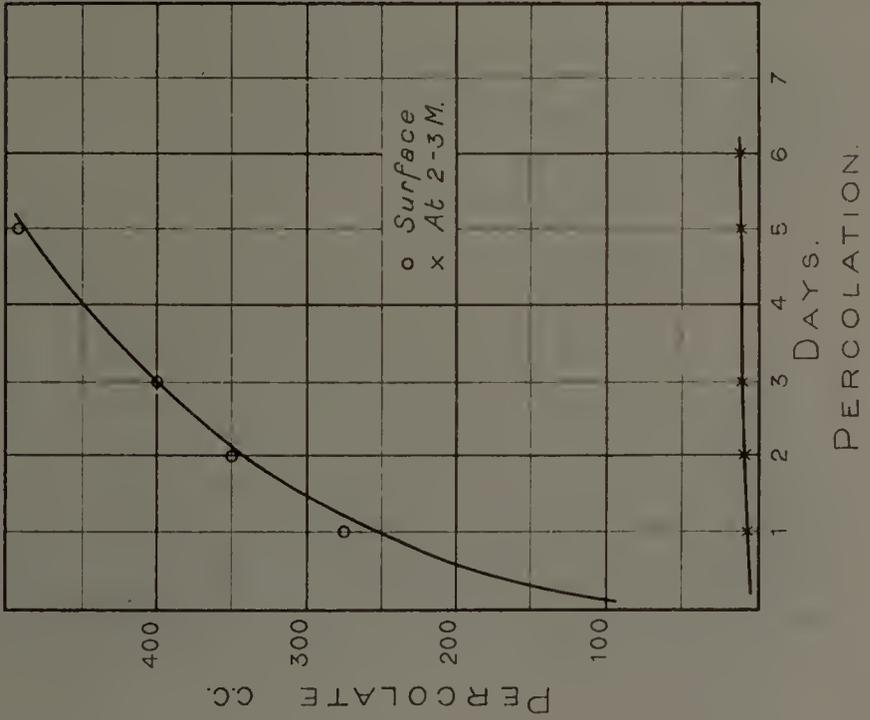


TABLE IV.—RATES OF PERCOLATION,  
UNDER SIMILAR CONDITIONS THROUGH SOILS NOS. 2 AND 4.

	Cubic Centimetres.	
	Surface No. 2.	2.3 Metres No. 4.
After 1 day ...	275	8.5
„ 2 days ...	353	12
„ 3 „ ...	400	13
„ 4 „ ...	—	—
„ 5 „ ...	492	18
„ 6 „ ...	526	20

That is to say that under similar conditions water percolates twenty-six times as quickly through the surface light soil as through the coarser material from a depth of two to three metres.

The fact that this sandy soil is of so slightly permeable a nature and that capillary movement of water is so extremely slow appears to indicate that there is little likelihood of salt being brought up from the lower layers unless the land were left without water for a very long period.

The following tables show the results of the analyses (mechanical and chemical) of the four typical varieties of soil mentioned on page 6.

TABLE V.—MECHANICAL ANALYSIS.

Size of Particles.	Fraction.	1.	2.	3.	4.
Millimetres.					
2-0.2	Coarse sand ... ..	0.8	1.3	1.9	7.5
0.2-0.02	Fine sand ... ..	11.9	42.6	20.0	52.6
0.02-0.002	Silt ... ..	18.7	15.7	12.0	9.0
< 0.002	Clay... ..	65.5	36.3	57.8	25.9
—	Soluble in water ... ..	3.1	4.1	8.3	5.0

NOTE.—The “fine sand” in No. 4 (from three metres) was much coarser than that in No. 2 (surface); the same sieve was used in both cases, so that the difference must be due to the fact that in one soil the majority of the particles of this fraction approach the dimensions of the upper limit (0.2 millimetre) while in the surface

light soils the particles forming the fraction called fine sand are much finer though still larger than the lower limit of this fraction, *viz.* 0.02 millimetre. It seems somewhat anomalous that the coarser material should be found in the less permeable soil. One is therefore bound to conclude that the impermeability is brought about by the presence of organic matter, as the small amount of clay (26 per cent) could not well be responsible, when the surface soil, containing the finer sand and more silt, is very permeable.

TABLE VI.—CHEMICAL ANALYSIS.

BY TWENTY-FOUR HOURS EXTRACTION WITH BOILING HYDROCHLORIC ACID.

	1.	2.	3.	4.
Loss on ignition ...	8.34	6.68	12.25	6.23
Insoluble and silica ...	52.48	59.10	53.42	—
Lime ... ..	2.45	3.55	1.60	—
Potash... ..	1.20	0.77	1.08	—
Phosphoric acid ...	0.32	0.32	0.21	—
Carbonic acid ... ..	0.63	1.07	0.39	—

TABLE VII.—PER CENT SALTS.

	Surface.	1 Metres.	2 Metres.	3 Metres.
Total salts ... ..	5.82	5.18	6.07	6.45
Sodium chloride ...	3.84	3.82	5.06	5.46
Sodium chloride per 100 total salts ... ..	66.00	74.00	83.00	85.00

From this table it will be noticed that the total amount of salts does not vary greatly throughout the three metres examined. The proportion of sodium chloride to the total shows some slight difference. This appears to indicate that some of the sodium chloride in the surface one and a half metres has been removed by the fresh water of the annual overflow which takes some of the more soluble salts from the surface layers of the soil. The greater part of the salt will be left behind as the water evaporated. The fact that there is less salt

in the surface layers than at two to three metres affords every indication that, with suitable drains, reclamation would be easy and rapid.

	1.	2.	3.	4.
Nitrogen ... ..	0.075	0.062	0.159	0.081
Organic carbon ...	0.60	0.39	2.22	0.82
Ratio $\frac{C}{N}$ ... ..	8.00	6.3	14.00	10.00
Ratio $\frac{\text{Loss on ignition}}{C}$	14.00	17.00	5.5	8.00

The organic carbon was determined by wet combustion with chromic acid after decomposition of carbonates, any hydrochloric acid (from the chlorides present) was removed by silver sulphate.

	Soluble in 1 per Cent Citric Acid (Dyer).		
	Per Cent.	Per Cent.	Per Cent.
Silica ... ..	0.452	0.672	0.416
Potash... ..	0.048	0.051	0.122
Phosphoric acid ...	0.040	0.034	0.042

The ratio  $\frac{C}{N}$  seems to show that the decomposition of non-nitrogenous material proceeds more rapidly in the lighter soil whether at the surface or at a depth of two to three metres.

The ratio  $\frac{\text{Loss on ignition}}{C}$  shows that in the sandy soils a larger proportion of the loss on ignition is due to organic matter and a lesser proportion to "Combined Water." This is entirely in accordance with experience, since it is the finer particles of the soil (fine silt and clay) which are composed of hydrated compounds, while the sand (coarse or fine) is almost entirely composed of silica containing little combined water.

#### SUMMARY.

(1) The soil of an area of 30,000 feddâns has been examined to a depth of three metres.

(2) The amount of soluble salts has been shown to be not excessive (Table VI) and sodium carbonate was rarely met with.

(3) Owing to the permeability of the surface soil the salt should be easily washed out if suitable drainage is provided. The almost entire absence of carbonate is favourable to this.

(4) The subsoil being of an impermeable nature there appears to be no reason why a rise of salts should be feared.

(5) Reclamation work on similar land at Kafr el Wekâla has proved most successful.

(6) The chemical composition of the soil does not differ from the average of Nile soils except that the amount of lime present is generally low. Potash and phosphoric acid are present in average quantity.

(7) A suggestion as to how the soil of this area has been deposited is put forward. This suggestion is based on the samples examined and takes no account of changes of level which may have taken place during and subsequent to the formation of the Nile Delta.

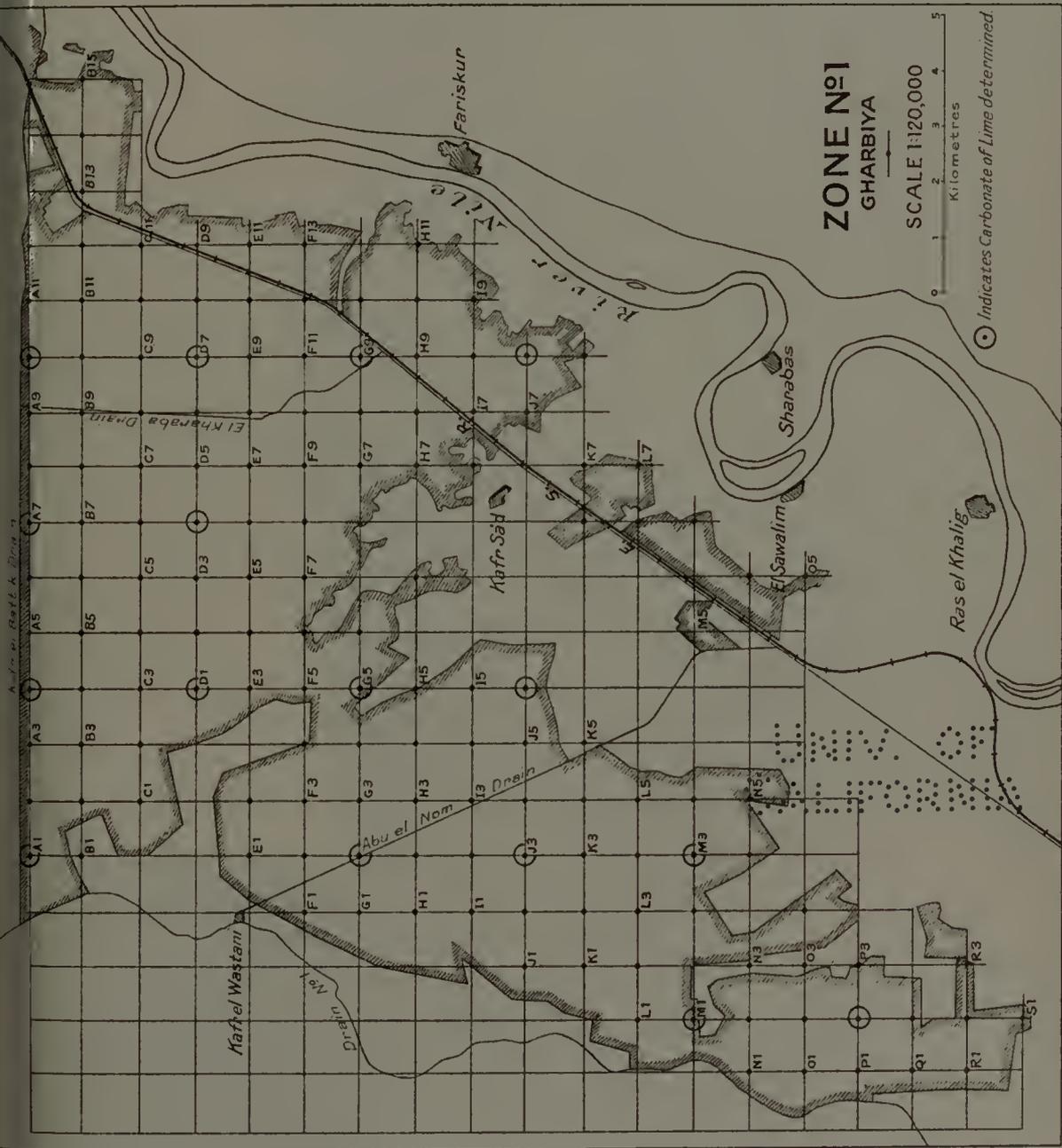
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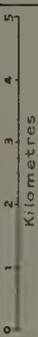
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A. 1. p. Batt. & D. 1.



**ZONE N°1  
GHARBIYA**

SCALE 1:120,000



○ Indicates Carbonate of Lime determined







YE 18904

