

REPORT
ON
THE SURVEY FOR THE DEVELOPMENT
OF THE RAILWAYS IN SUDAN


1961

EXHIBIT TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

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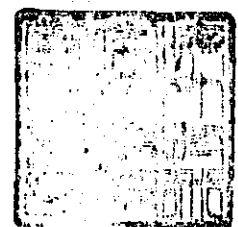
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JULY 1965

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN



国際協力事業団

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P R E F A C E

The Government of Japan, in response to a request from the Sudan Government, entrusted to the Overseas Technical Cooperation Agency (OTCA) the task of conducting a preliminary survey in the Sudan. The OTCA, fully realizing the importance of the Development Program of the Railways in the Sudan, organized a seven-member team of experts and dispatched it to the Sudan on February 3, 1965 for a two month on-the-spot survey under the leadership of Dr. A. Eto, a Member of the House of Councilors.

The OTCA, which was established on July 1, 1962, serves as an executing agency of the Japanese Government to conduct Japan's government-level technical cooperation to Asia the Near and Middle East, Africa and Latin America. Its principal activities are acceptance of overseas trainees, assignment of technical experts, establishment of overseas technical cooperation centers and the conducting of preliminary surveys for development projects.

It is my sincere hope that this report will prove to be useful in the field of technical help to the Development Program of the Railways in the Sudan and will also help to foster closer technical ties and better understanding between the Sudan and Japan.

Lastly, on behalf of the OTCA, I wish to take this opportunity to express our greatest appreciation and sincere thanks to the various agencies of the Sudan Government for their invaluable help and cooperation given to the Survey Team, without which it would not have been possible for the Team to conduct a smooth survey on the spot.

July 1965



Shinichi Shibusawa
Director General
Overseas Technical Cooperation Agency
of Japan

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I INTRODUCTION

1. Objective of Survey

This survey investigates the possibility of the construction of a transport route which would link El Fasher, Nyala and El Geneina, and which would present itself as one of the imperative projects in pushing forward the economic development of a vast area with J. Marra, Darfur Province, as its centre.

In order to attain this objective our team executed the following two operations:

- (1) Preparation of a plan for the construction of a railway to run between Nyala and El Geneina.
- (2) Preparation of a plan for the improvement of a road between El Fasher and Nyala.

2. Our Survey Team was comprized of the members:

Capacity	Names	Occupations & Titles
Leader	Dr. Akira Eto	Member of the House of Councillors, Dr. of Engineering
Deputy leader	Mr. Hayao Kasuya	Chief of Planning Dept. of the Japan Railway Construction Corporation
Member	Mr. Jiro Hiraoka	Chief of Engineering Section, Engineering Dept. of the Japan Railway Construction Corporation
"	Mr. Haruo Yoshinaga	Chief of Engineering Section, Shimōnoseki Branch of the Japan Railway Construction Corporation
"	Mr. Tetsuo Hanya	Chief of Yard Engineering Section, Tokyo Construction Division, of the Japanese National Railways
"	Mr. Masakuni Saisho	Member of the Technical Affairs Office, the Japan Overseas Technical Cooperation Agency

3. Day-to-day Programme of Survey according to the leader and other members.

Leader

Date	the Day of the Week	Starting from	Arrival at	Description	Accommodation etc.
January					
30th	Saturday	Tokyo			
31st	Sunday				
February					
1st	Monday		Paris		
2nd	Tuesday				
3rd	Wednesday	Paris			
4th	Thursday		Fort Lami	Talked with the Chad government concerning the planning of the Trans continental Railroad of Africa.	
5th	Friday				
6th	Saturday				
7th	Sunday	Fort Lamy	Lagos		
8th	Monday			Talked with the Nigeria government concerning the planning of the Transcontinental Railroad of Africa.	
9th	Tuesday	Lagos	Khartoum	Joined the team.	Khartoum
10th	Wednesday			Consulted with the Japanese Ambassador.	"
11th	Thursday			Paid a courtest call on the Ministers of Works and Communications, the General Manager of Sudan Railways, Minister of Finance, and Deputy of Ministry of Finance.	"
12th	Friday			Inspected the Khartoum District.	"
13th	Saturday	Khartoum	Atbara	Courtesy visit to Deputy of Sudan Railway.	Atbara
14th	Sunday			Held discussions with General Manager, Deputies and Chieves of Departments, etc.,. Showed the film "Diesel Express" presented by the Japanese National Railways.	

Date	the Day of the Week	Starting from	Arrival at	Description	Accommodation etc.
15th	Monday	Athara	Port Sudan	Deputy leader, Kasuya joined in the trip. Visited the Port Manager and inspected the port facilities.	on the train
16th	Tuesday	Port Sudan	Port Sudan	Inspected the District of Port Sudan. Deputy leader, Kasuya joined.	on the train
17th	Wednesday		Khartoum		Khartoum
18th	Thursday			Inspected the Khartoum District.	"
19th	Friday			Holiday	"
20th	Saturday	Khartoum	El Fasher	In company with Deputy leader, Kasuya. Discussed matters with the Commissioner of Darfur Province.	El Fasher
21st	Sunday	El Fasher	Suni	Inspected the area between El Fasher and Suni.	Suni
22nd	Monday	Suni	Nyala	Inspected the development programme for the Suni-Kas-Nyala and J. Marra areas.	Nyala
23rd	Tuesday			Inspected the Nyala district.	"
24th	Wednesday			"	"
25th	Thursday	Nyala	Geneina	Inspected the Geneina district.	Geneina
26th	Friday	Geneina	Khartoum	Talked with the team members concerning the field investigation.	Khartoum
27th	Saturday	Khartoum		Left for Japan.	

Members of the team

Date	the Day of the Week	Starting from	Arrival at	Description	Accommodation etc.
February					
7th	Sunday	Tokyo			In the airplane
8th	Monday		Khartoum		Khartoum
9th	Tuesday			The leader of the team arrived	"
10th	Wednesday			(Accompanied with the leader)	"
11th	Thursday			"	"
12th	Friday			"	"
13th	Saturday	Khartoum	Atbara	"	Atbara
14th	Sunday			"	"
15th	Monday			Heard reports from the Chief Mechanical Engineer and Chief Engineers as to the situation and collected information.	"
16th	Tuesday			Inspected factories making semaphores, cement and sleepers. Listened to reports by the Traffic Manager and others concerning the situation and collected information data.	"
17th	Wednesday			Inspected a car factory. Noted the explanations made by the General Manager and Development Engineer. Collected information.	"
18th	Thursday			Situation was explained by the Chief Accountant. Collected necessary data.	on the train
19th	Friday	Atbara			"
20th	Saturday		Port Sudan	Situation was explained by the Port Manager. Inspected the facilities of the harbour.	Port Sudan

Date	the Day of the Week	Starting from	Arrival at	Description	Accommodation etc.
21st	Sunday			Inspected the Port facilities and the extension work now under way.	Port Sudan
22nd	Monday			Visited Suakin.	"
23rd	Tuesday	Port Sudan	Khartoum		Khartoum
24th	Wednesday			Studied reports concerning the area between Nyala and Geneina	"
25th	Thursday			"	"
26th	Friday			Joining the leader and deputy leader, making arrangements as to the schedule for the field investigation.	"
27th	Saturday			the leader returned to Japan. Made preparations for field investigation.	"
28th	Sunday			Inspected the district of Khartoum.	"
March					
1st	Monday	Khartoum	Nyala	Talked with the commissioner of Darfur Province and others. Inspected Nyala Station.	Nyala
2nd	Tuesday			Made arrangements with the Commissioner of Darfur Province and Others. Investigated the condition of the existing railroad between Nyala and Bileil. Investigated the location where a bridge is to be constructed in W. Nyala.	"
3rd	Wednesday			Investigated the condition between Nyala and W. Dussul Dagga.	"
4th	Thursday	Nyala	Kas	Investigated the condition between W. Dussul Dagga and Kas.	Kas

Date	the Day of the Week	Starting from	Arrival at	Description	Accommodation etc.
5th	Friday			Investigated the condition between Kas-(New Road)-Koronli.	Kas
6th	Saturday	Kas	Zalingei	Investigated the condition between Kas-(old road)-Zalingei.	Zalingei
7th	Sunday			Investigated the condition between Zalingei-(new road)-Koronli.	"
8th	Monday			Visited U. N. S. F. J. Marra Project. The development programs and the progress of investigations were explained by the officials. Investigated Zalingei and near by areas.	"
9th	Tuesday			Investigated the condition of the areas between Zalingei-(new road)-Kurgula-Sullu-J. Bura and between Kurgula-(old road)-Korei-Zalingei.	"
10th	Wednesday			Investigated the condition Zalingei-Korei-(closed road)-Fongfong-Hugeir and J. Bura.	"
11th	Thursday	Zalingei	Geneina	Investigated the condition between Sullu-Murnei-Geneina.	Geneina
12th	Friday			Investigated the condition of area between Geneina and Kereinik.	"
13th	Saturday			Investigated the condition of area between Geneina and Adre.	"
14th	Sunday			Sorted and put in order the data collected.	"
15th	Monday	Geneina	El Fasher	Inspected the condition between Geneina, Kebkabiya and, El Fashar.	El Fasher
16th	Tuesday			Made a rough report to the Commissioner of Darfur Province outlining construction of a railroad between Nyala and Geneina.	"

Date	the Day of the Week	Starting from	Arrival at	Description	Accommodation etc.
17th	Wednesday			Investigated the district between El Fasher - (central road) - Musko - (Eastern road) - El Fasher	El Fasher
18th	Thursday	El Fasher		Investigated the condition between Musko and Nyala	Nyala
19th	Friday	Nyala	Suni	Investigated the condition between Menawashei and Melemm.	Suni
20th	Saturday			Sorted and put in order all data that was made available.	"
21st	Sunday	Suni	El Fasher	Investigated the condition between Melemm - (Western Road) - El Fasher.	El Fasher
22nd	Monday	El Fasher	Khartoum	Made an interim report to the Commissioner of Darfur Province concerning the planning of all Weather Road between El Fasher and Nyala.	Khartoum
23rd	Tuesday			Made a similar report to the Japanese Ambassador.	"
24th	Wednesday			Inspected the Khartoum district.	Khartoum
25th	Thursday	Khartoum	Atbara	Discussed matters with the Chief Engineer.	Atbara
26th	Friday			Inspected the Atbara district.	"
27th	Saturday	Atbara	Khartoum	Made a report to the General Manager.	Khartoum
28th	Sunday			Made a similar report to the Deputy of Ministry of Finance.	"
29th	Monday			Made a similar report to the Minister of Works.	"
30th	Tuesday	Khartoum		Left for Japan.	

4. The Sudanese personnel concerned

Following is a list of the main persons concerned with the study on the part of Sudanese government. We express our hearty thanks for their cooperation.

Central Government

Mubarak Zarouk	- Minister of Finance and Economics
Abdel Rahim Mirghani	- Deputy, Ministry of Finance and Economics
Abdel Rahman El Agib	- Minister of Works and Mineral Resources
Azboni Mandiri	- Minister of Communications

Sudan Railways

A. A. Rida	- General Manager
A. E. Hummeida	- Deputy
Ismail Hussen	- Deputy
Naim Ghandour	- Chief Engineer
S. F. Sidhom	- Chief Mechanical Engineer
Gassim Magdoub	- Chief Accountant
A. Rahman Nadeem	- Traffic Manager
Hassan Abboud	- Port Manager
Abdel Honeim Abbas	- Assistant Chief Engineer
Ahmed Fadl	- Development Engineer
Hassan Omer	- Traffic Research Officer
Nasr Eldin Mustafa	- Resident Engineer, Harbour Extension
Ibrahim Hussan Babiker	- Engineer, Engineer Department

Dafur Province

Tagani Saad	- Commissioner
Ahmed Ali Abdalla	- Information Officer
Khedr Khalafall	- Chief Engineer
Saud Makawi	- Inspector, Nyala
Mahagob Bakker Karmali	- Inspector, Zalingei
Osman Abdel Rahim	- Inspector, El Geneina

U. N. S. F. Jebel Marra Project

A. J. Bakker	- Project Manager
Mahmoud Bashir Jamaa	- Co Manager
A. Oge	- Road Planning and Irrigation Engineer

II SURVEY OF THE RAILROAD BETWEEN NYALA AND GENEINA

1. Organization of the Survey Team and the Apparatus used

The Survey Team was composed of five Japanese members, including Mr. Kasuya, and Messrs. Ahmad Ali of the Sudanese government (Information Officer, Darfur Province) and Ibrahim Hassan Babiker of the Sudan Railways. The hands required for the expedition were as follows:

Cooks and Waiters	2 persons
Policemen on guard (One of them also served as a driver)	3 "
Drivers	2 "
Assistant drivers	3 "
Automobile Repair Man	1 "
Labourers employed on the spot	5 "
	<hr/>
Total	16 persons

The principal instruments for surveying which the Survey Team had brought from Japan were as follows:

Theodolite (Wild T2)	1
Plane Table and Alidade	1
Hand Levels	2
Barometers	2
Tape	1

Principal apparatus for the survey provided by the Sudan Railways were as follows:

Tents	7
Traveling beds with blankets and sheets	6
Chairs	8
Desks	4
Washbasins	4
Tilly lamps	4
Water tanks capable of holding 15 gallons	10
Paraffin paper for cooking	

Foods, utensiles, etc.

The automobiles provided by the Darfur Province were as follows:

Land Rovers	2
Lorry (5 tons)	1

2. Method of Survey

(1) Maps used

Maps on the scale 1:250,000 covering the whole areas to be surveyed were made available. Among those that were used are as follows:

54 - M	Nyala	(Dec. 1944)
54 - P	Zalingei	(Dec. 1937)
53 - L	Kereinik	(June 1938)
53 - K	Geneina	(Dec. 1938)

On the strength of these maps, it was possible to plan routes in advance and the schedule of the survey party was decided accordingly. The results of the actual survey proved these maps to be fully reliable with only slight discrepancies, occasionally, in the roads. The surveying was done more than 20 years ago and since that time no surveys for correction and adjustment have been carried out. Of course new roads are not recoded and many roads on the maps are no longer in use. The altitudes of Kas and Dibbis shown on the maps proved much different from the figures of the survey results of our team. The W. Dimatulei and the W. Dodo shown in the Zalingei map seem quite different when compared to actual conditions.

Maps of one one hundred thousandth were available together with those of one two hundred and fifty thousandth. The section where such maps were utilized was between Kas and Mumu. These maps were of great use as the features of wadis had been drawn minutely from aerial photographs and yet they showed almost the same contour lines as the maps of 1:250,000.

Also available were the aerial photographs on a scale of 1:24,000 showing the straight distances between Nyala and Zalingei and between Zalingei and Geneina, which were of considerable help to our activities. We also found in the Jebel Marra Project Office at Zalingei an aerial photograph for the distance between Kas and Zalingei, but it had little value because

it was only masaiched and was not a contour map.

(2) Specifications of Tracks

As regards the specifications of tracks, the following standards were decided.

Average gradient	0.8%
Minimum radius of curvature	400m
Weight of rail	50 pounds per yard
Sleeper arrangement	12 pieces every 30'
Width of formation	4.2m
Effective length of main track in station yard	450m
Block system	Tablet instrument block system
Signal	Semaphore signal
Interlocking system	Point detector

(3) Method of Investigation

We drove a Land Rover along the roads near the routes selected on the maps of 1: 250,000, and field reconnaissance was made at places off the roads where necessary. The widths of main wadis were measured by means of taping.

As regards the height of ground surface, the altitude was calculated in comparison with the figures of air pressure observed at the places where the altitudes had already been ascertained through observations using two sets of barometer.

Where any clear landmarks were unavailable and the actual locations could not be ascertained on the map, Wild T2 helped us through observations of the sun.

(4) Water Level at the time of the Floods

Regarding the water level under flood conditions and the relation between the level and the flood hours, the observed figures of the Jebel Marra Project were used for reference.

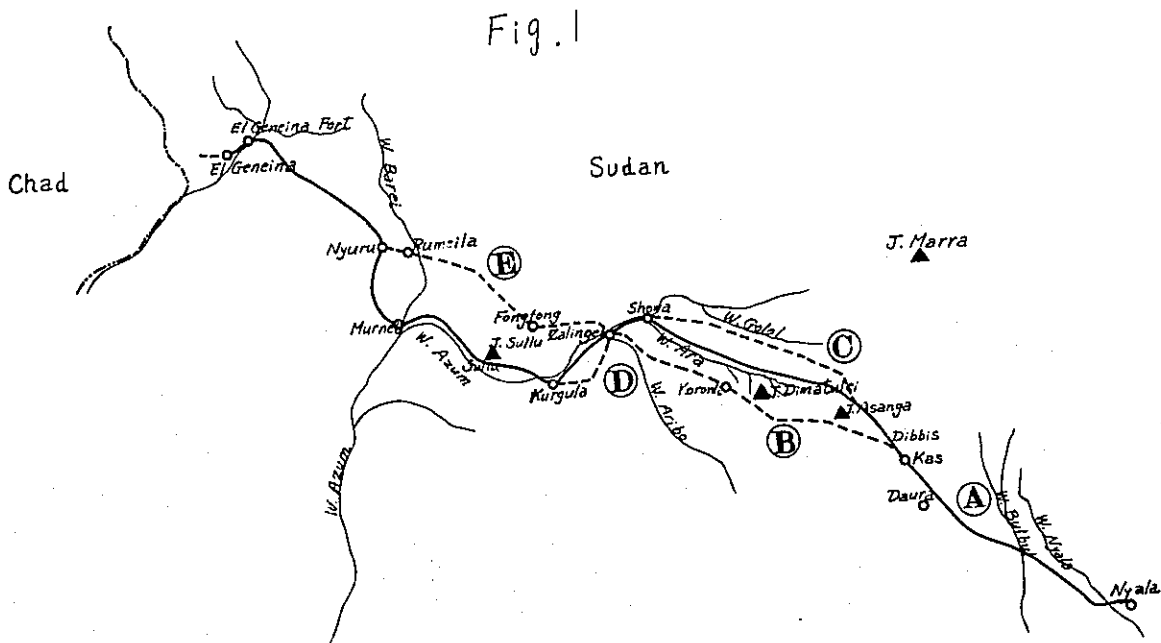
3. The Routes Selected

Concerning the route between Nyala and Geneina, the results of the survey lead us to recommend Route A shown in Fig. 1 and Fig. 2 attached. This route starts from Nyala and runs west along the old road via Kas and Dibbis and, crossing the watershed ridge between Lake Chad and the White Nile, comes up to Zalingei along the Wadi Ara and runs to Murnei along the Wadi Azum and to El Geneina via Nyuru and Geneina Fort. The total length of the

track would be about 366Km. (Please refer to figures 4 and 6)

Upon selecting the route between Nyala and Zalingei, the routes other than Route A aforementioned, such as Route B running along the new road between Dibbis and Zalingei and Route C starting from the Watershed and running westwards over the tableland between Wadi Ara and Wadi Golo to reach Zalingei, have been brought into close comparison as shown in Fig. 1. (see 5)

As to the route between Zalingei and Geneina, two routes in addition to Route A have been carefully considered. One is Route D which runs along the new road from Zalingei to Kurgula where it joins Route A, and the other is Route E which runs from Zalingei to Nyuru, via Fongfong and Rumeila, and Joins Route A there. They are shown in Fig. 1 as per the attached. (see 7)



4. Route between Nyala and Zalingei

As to the route between Nyala and Zalingei, the one along the old road may be recommended as shown in Fig. 1 and Fig. 2. In regard to this route the points which need special attention are as follows:

(1) The railway at Nyala station now in use faces south and north. In order to change the route in the direction of Kas, the tracks must go round the airdrome. Taking into consideration the height limitation against the aeroplanes, it may be desirable that the route should run through at a point near the centre between the end of the runway and the channel of W. Kulkul. The vicinity is free from any flood risk even in the rainy season and the condition of its soil is comparatively good for construction work.

(2) The crossing over the W. Nyala at a point about one hundred meters north of the present road may be suitable. At this point there crop out the beds of gneiss on both banks, and the Wadi is narrow and steadyfast.

(3) The route must also cross the road between Nyala and Zalingei and pass through the southwest of that road. The topography shows the land is more level as compared to the northeast side of the road, and Khor is situated upriver where the stream is narrowed which should make the span of the bridge smaller.

(4) The point where the road now crosses W. Bulbul is extremely precarious and it is feared that the stream will change during rainy season. Therefore, the railroad is scheduled to cross the Wadi at a point about 2 Km up from the place where the road crosses. The number of the spanning points may be increased, but the water channel must become more constant and the total length of spanning shorter.

(5) At a point near the border between the Western and Southern Districts, a new road has been cut to lead straight to Kas without passing through Daura. The route of the railroad must also be constructed along, and at the northeastern side of, this new road. The topography is very even and the soil is good.

(6) Kas is situated at the centre of this district and a railway station should no doubt be constructed here. The recommended site of the station will be in the east part of the town. It is recommended that another station be built at a place about 111Km. It will contribute greatly to the transportation of agricultural products to be harvested in the future from the southern part of J. Marra as the district is developed.

(7) In order to cross over the watershed north of J. Asanga, the route must be selected further north of the old route. In this case the volume of earthwork may be increased to some extent, but it is possible to lower the highest point and decrease the number of bridges.

(8) After crossing over the watershed, the route must run along the north side of W. Ara till a point 179Km. There are fewer wadis and khors as compared to the south side. However, as the route thus runs along the W. Ara bank, protection works at every key point will become necessary.

(9) It is recommended that the crossing of the W. Ara be near Showa Village. A route which runs along the old road and leads to Zalingei is not advisable from the view point of grading as well as from the volume of earthwork. On the other hand, if a route runs from Showa village through the north of Hamidiya, going round the aerodrome, a flat line may be expected which is safest even in flood time. Besides, in this case steady cross points of the W. Aribo will be available.

(10) The site for the station of Zalingei may be selected at the north part of the town. In this case some native dwellings of strawroofed hut must be removed.

5. Comparable Routes with the One between Nyala and Zalingei

As regards the comparable routes, two routes such as B and C Routes of Fig 1 as mentioned in above 3 should be considered.

(1) Route B

As a route connecting Nyala and Zalingei, one, a comparable route, may come into focus. This route runs along the new road and crosses over the watershed at the south side of J. Asanga. Although this route may enjoy the advantage of being least affected by the rainy season, the route will necessitate voluminous earthwork as it is restricted in the standard of gradient. The altitude of the watershed on this route is 1160m which is higher than the summits of the first recommended route, and heavy gradient construction work may become necessary.

This route, which only passes through at a distance from Kas and Zalingei will also be of no great use for the development of the areas, as only a few villages are dotted here and there near Koronli all along the route. On the other hand, however, the old road finds villages and cultivated fields all along its length, with the exception of a distance of about

20Km centering in the watershed where it is not inhabited, and if railway stations would be built one after another along the line in proportion to future development, the communication possibilities in this territory would be greatly enhanced.

(2) Route C

This is the route which runs west from the watershed along the old road and over the tableland between the Wadi Ara and the W. Golol. The route may not suffer much from flood, but its vital defect is that it runs along a steep slope all the way down to Zalingei.

6. The Route between Zalingei and Geneina

For the route between Zalingei and Geneina, a route which runs to Murnei along the W. Azum and to Geneina may be recommended. Concerning this route due attention must be paid as follows:

(1) A route along the left bank of the W. Azum must be selected. On the right bank of the W. Azum, namely, along the old road, there extends a stretch of broad fields which is advantageous of course, however, in order to construct a station at Kurgula, the W. Azum must be crossed two times more and the construction cost would increase proportionately, which would pose greater disadvantages.

(2) Kurgula is the centre of this district and it is necessary that a station be constructed here at the north of the town.

(3) In Saraf the route is scheduled to cross the W. Azum at a point upstream of the existing road and go down the wadi along its right bank. Utmost care is required when the route passes through the area where J. Sullu reaches the W. Azum and heaves upon it. J. Sullu consists of crystal-line schists and its cliffy skins incline about 14-15 degrees to the south, where there is always the possibility of stratum sliding if the rocks are cut off. Therefore, it is advisable that the line passes through on the dike where protection work have been built in the wadi's beds.

(4) Along the W. Azum there stretches a cultivated land area and as Sullu is in the centre of this district, a station should be constructed there. Mumu and its vicinity are well developed, serving as a door for the cultivated hinterlands such as Huger and Burubaasi. The localities should be so arranged as to have a station put up if conditions necessitate it in future.

(5) As regards the localities along the W. Azum, the construction height of the formation level must be decided by taking into consideration the water-level of the W. Azum in flood time and revetment work must be done at every important point.

(6) A station should be constructed at Murnei where the line is to cross the W. Barei, one of the branches of the W. Azum. The W. Azum's basin is well cultivated and populous with many villages all the way down to the Lower Murnei. There is a road to Murnei connecting those villages, and a station situated at Murnei would become the entrance to the areas of the Lower W. Azum.

(7) As to the area from Murnei to Nyuru, the topography seems very even and the soil is excellent except patches of heavy sandy waste existing in between. This should make the cost of construction of a railroad through the area most inexpensive.

(8) From Nyuru Geneina there extends a comparatively steep land. However, the topography is not very uneven and it will be easy to select a proper line of mild slopes through which an economical, though indirect, route, may be constructed.

(9) The area between Nyuru and Geneina consists of sandy wastes. Fortunately, the government plantation policies have been successful in this locality and the sand seems settled. Upon construction of a railroad here the plantation areas along the line must be protected and taken care of.

(10) A station may be set up at the south end of El Geneina Fort where the W. Kaja is to be crossed. From this spot the line is to turn to the south, pass through the west part of El Geneina and further turn to the west. El Geneina Station may be constructed north of the custom house. This site provides enough space to install all necessary facilities of a terminal station and also the advantage of controlling entry of the seasonal cotton picking labourers and facilitating their transport.

7. A Comparable Line between Zalingei and Geneina

As to other lines considered in this section, D and E Routes aforementioned in 3 are thought possible as shown in Fig. 1.

(1) Comparable Line D

The topography along the comparable line D which leads to Kurgula from Zalingei along the new road is comparatively even till reaching Gulla, but further to Giri there are

found many deep cutting khors. Consequently the volume of earthwork will increase and many structures such as bridges and drain pipes, etc. will become necessary. For the line between Giri and Kurgula, a steep gradient cannot be avoided. For this reason, Route A which is even and runs along the W. Azum is thought advantageous even if the line should necessitate some structures such as revetment or others for the section between Zalingei and Kurgula.

(2) Comparable Line E

Upon planning the line from Zalingei to Geneina, Route E can also be considered. This Route does not run along the W. Azum but is to cross the Wadi immediately after leaving the station of Zalingei, and runs west wards over the plain land to Korei and then to Fongfong along an abandoned road which is not in use. It will then turn north-north-east, go through Burubassi and Hageit, turn again to north-west-west, cross the W. Barei at Rumeila and join the aforementioned route at Nyuru. Judging from a point of view hitherto entertained, such a route would be safe from flood during the rainy season as the route does not run along the W. Azum. However, from the topographic point of view, a line which is of comparatively even surface can be constructed for the section of Geneina-Korei-Fongfong, while the land features between Fongfong and Burubassi seem quite intricate, many wadis and khors being found, and thus the selection of this line cannot be made unless a steep gradient is applied. The area from Burubassi to Rumeila is comparatively even in ground surface. In the vicinity of Korei and Burubassi only a few sections of cultivated land can be seen and the other parts remain almost waste. Few cattle may be seen in this district. Economically, this district is quite unfavorable as compared to the W. Azum's basin.

The views hitherto maintained that this route is favorable for a safe and strong line even in rainy season, and with traditional cheap construction costs, may easily be proved erroneous, taking the fact into consideration that a new road which is to connect the stations of the line and the farm product growing districts must be constructed and enormous transportation expenses demanded.

8. Construction Cost

The cost which is necessary for the construction of a railroad of 366 km between Nyala and Geneina is estimated at Sudanese £5,609,500 or Sudanese £15,300 per 1km.

As to the rail construction, if the secondhand rails which will be available from the change of heavy rails of Sudan National Railways would be used as the materials, the total construction cost will decrease to £s4, 289, 700 or £s11, 700 per lkm.

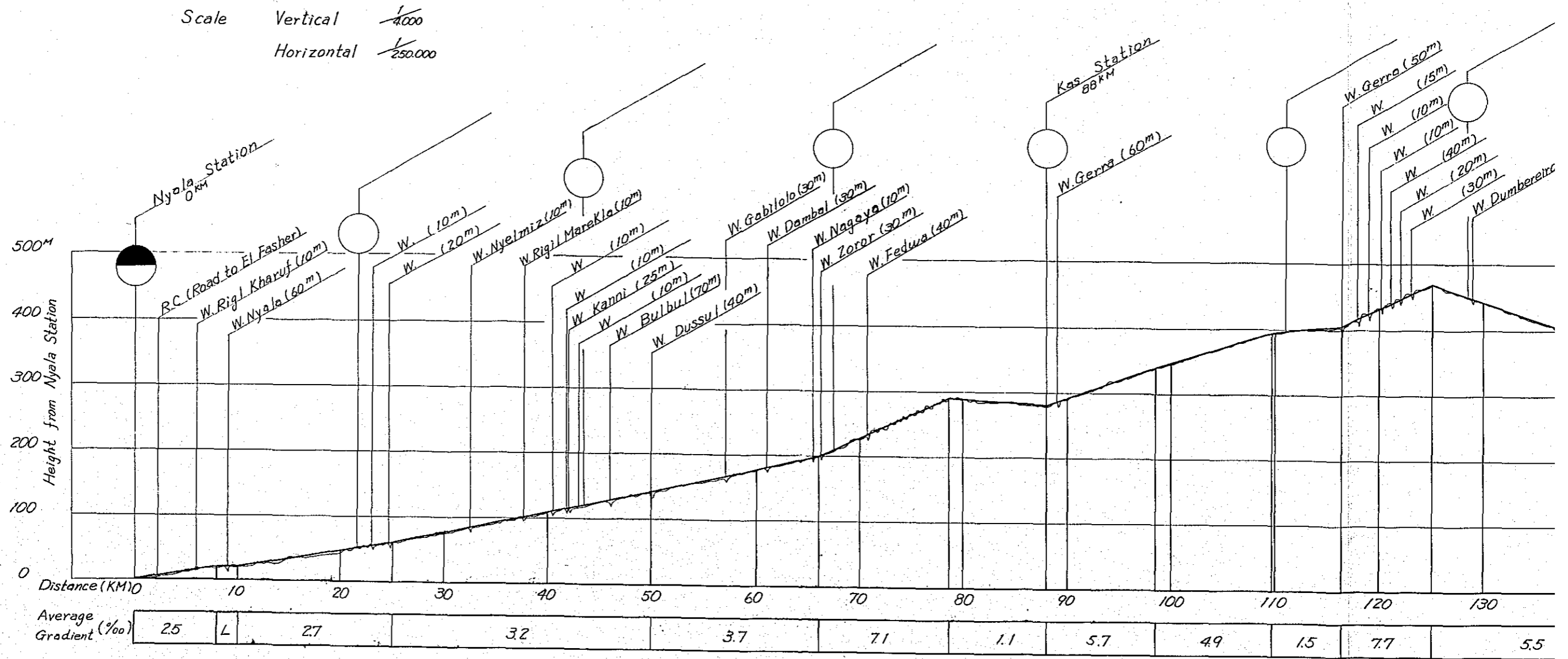
These figures by the sections are as shown in Table 1.

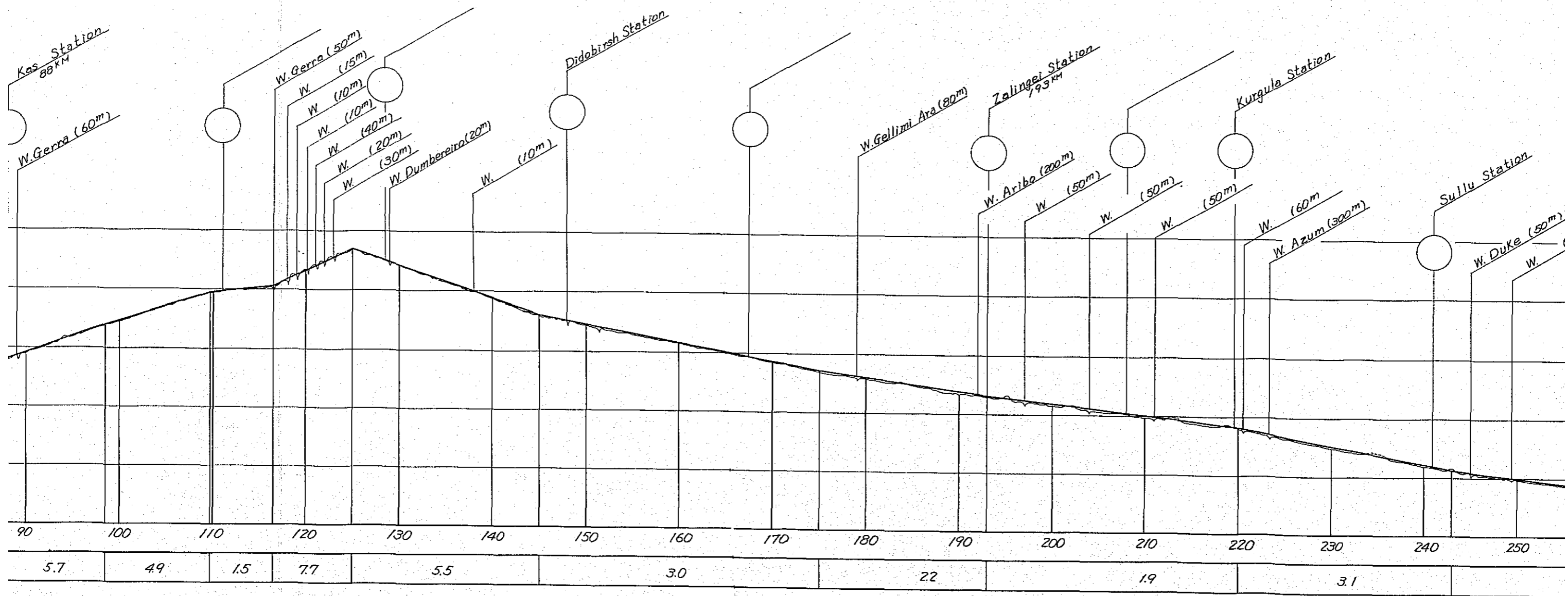
Table 1 Cost of Construction of Railways between Nyala and El Geneina
(Excluding Overhead Expenses and Cost of Rolling stocks)
(Unit: Sudanise £) () ; if the Second Hand Rail and Sleepers would be used

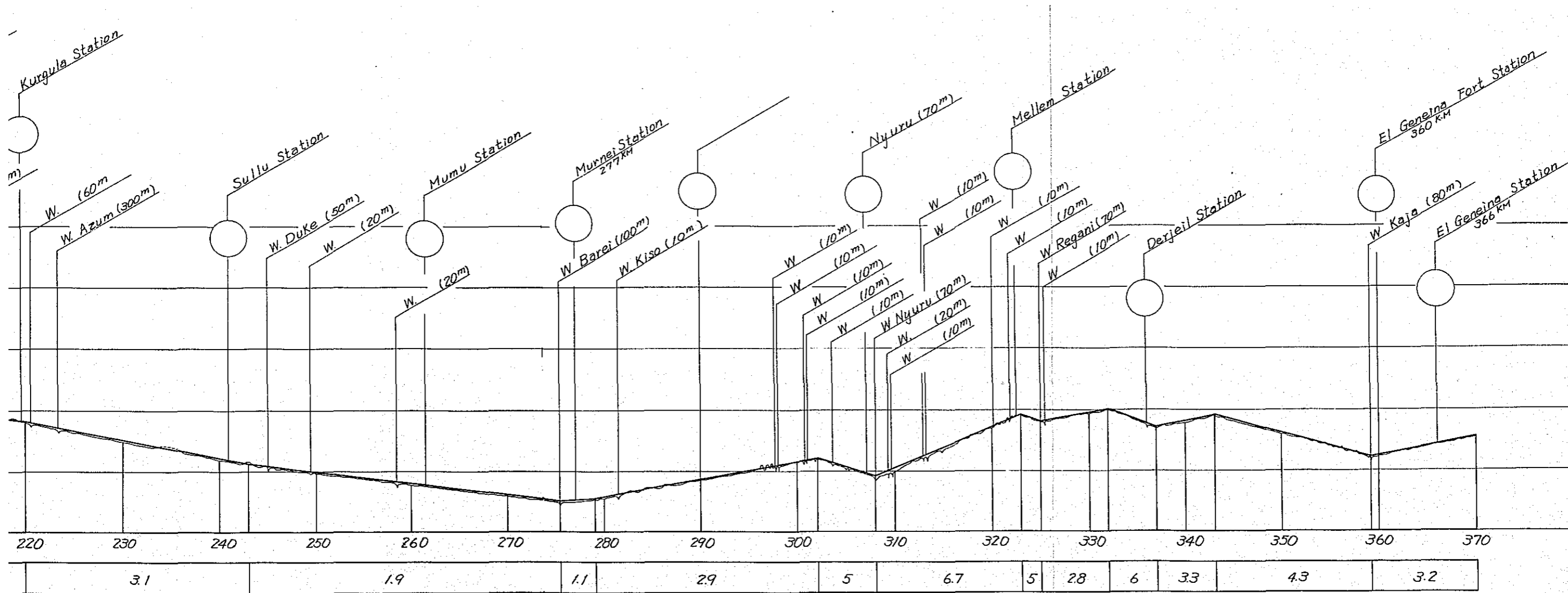
Items		Unit Price £s	Nyala - Zalingei 193 KM		Zalingei - Geneina 173 KM		Total 366 KM	
			Quantities	£s	Quantities	£s	Quantities	£s
Perma- nent Way	Bush Cleaning	12/KM	193 KM	2, 300	173 KM	2, 100	366 KM	4, 400
	Earth Work	0, 15/m ³	3, 010, 000 m ³	451, 500	2, 570, 000 m ³	385, 500	5, 580, 000 m ³	837, 000
	Bridge	400/m	970 m	388, 000	1, 060 m	424, 000	2, 030 m	812, 000
	Culvert	1, 000/spot	150 spot	150, 000	125 spot	125, 000	275 spot	275, 000
	Drain	200/KM	193 KM	38, 600	173 KM	34, 600	366 KM	73, 200
	Protection Work	8/m ²	10, 000 m ²	80, 000	19, 000 m ²	152, 000	29, 000 m ²	232, 000
Track	Main Track	5, 500/KM (2, 500)	193 KM	1, 061, 500 (482, 500)	173 KM	951, 500 (432, 500)	366 KM	2, 013, 000 (915, 000)
	Side Track	5, 500/KM (2, 500)	11 KM	60, 500 (27, 500)	13 KM	71, 500 (32, 500)	24 KM	132, 060 (60, 000)
	Turnout	470/set (190)	48 set	22, 600 (9, 100)	58 set	27, 300 (11, 000)	106 set	49, 900 (20, 100)
Station (including Building and Water Supply)	Large Station	40, 000/spot	2 spot	80, 000	3 spot	120, 000	5 spot	200, 000
	Small Station	7, 500/spot	7 spot	52, 500	7 spot	52, 500	14 spot	105, 000
Signalling and Telecommunication		1, 000/KM	193 KM	193, 000	173 KM	173, 000	366 KM	366, 000
Expenses incidental to the construction work		(10%)		258, 100 (105, 500)		251, 900 (104, 500)		510, 000 (390, 000)
TOTAL				2, 838, 600 (2, 150, 500)		2, 770, 000 (2, 139, 200)		5, 609, 500 (4, 289, 700)
Cost/KM				14, 700 (11, 100)		16, 000 (12, 400)		15, 300 (11, 700)

Fig. 2 (Refer to the end of the book)

Fig 3 Profile of the Railroad between Nyala and El Geneina







III ROAD SURVEY BETWEEN NYALA AND EL FASHER

1. The Circumstances which lead to our survey

On February 20th, our team leader, Mr. Eto visited the Governor of Darfur province at El Fasher. It was requested that he execute a Road Survey between Nyala and El Fasher in addition to the survey of the railroad between Nyala and Geneina. The request had previously been made by the Sudan government, but it was decided on the Japanese part that only the Railroad Survey Team was to be sent. However, the Governor of Darfur Province was very hopeful that the entire project be undertaken, so our team decided after all to take charge of a general survey of the road between Nyala and El Fasher.

2. Wishes expressed by the Governor of Darfur Province

El Fasher is the capital of the Darfur Province and Nyala is the terminal of the existing railroad. Both towns must be connected by roads available for passage all the year round. The roads now connecting both cities have three routes as shown in Fig. 4. The three roads are as follows:

- (1) East Route (A) Nyala - Menawashei - Musko - Shingil Tobaya - Gharraqu - El Fasher
- (2) Centre Route (B) Nyala - Menawashei - Musko - El Fasher
- (3) West Route (C) Nyala - Menawashei - Melemm - Tarni - El Fasher

East Route (A) has many villages along its line and enjoys much utility value, but during the rainy season it becomes muddy and passage becomes impossible.

Centre Route (B) passes through sandy wastes. Though this is the shortest route during the dry season the passage of cars becomes difficult.

West Route (C) also passes through sandy waste, and, what is worse, it has the longest distance, and so it might be excluded from our survey.

3. Organization of Survey Team

This survey being different in nature from that of the railroad received no assistance from the Sudan Railways, and all arrangements were made in Darfur Province.

The members of this team consisted of 5 persons under Mr. Kasuya's leadership. Mr. Ahmed Ali took charge of all arrangements during the whole course of the journey.

Other needed workers were the following 5 persons:

Drivers	2
Car repair man	1
Cook	1
Odd job man	1

on the first day 2 Land Rovers were used, but one was damaged and was replaced by a jeep the next day.

4. Method of Survey

The maps of 54-M Nyala on the scale of 1:250,000 and of 54-I El Fasher on the same scale were used. The survey instrument used in this investigation were nothing but a tape and a barometer. The position and width of wadi, necessary positions of drain pipes and the nature of soil, etc. were measured and recorded in accordance with the running distances of cars.

5. The District between Nyala and Menawashei

This section constitutes a part common to all routes.

(1) The topographical features of this section are that it is hilly and has many wadis and khors. Many bridges, culverts, drain pipes and others must be constructed.

(2) The nature of soil is comparatively good though partly muddy and banking construction by good soil is necessary.

(3) When a road bed is to be constructed on the slope of a hilly district, the sidegutters should be installed at the upper side of the slope to lead any running water into the drain pipes or wadi.

6. The District between Menawashei and Musko

This section constitutes a part common to East Route and Centre Route.

(1) In this district the route meets the W. Amer immediately after leaving Menawashei and only a few khors are found.

(2) Topography is even, but some places would become muddy in rainy season. Banking construction and the construction of side gutters are necessary.

7. East Route (A) which goes between Musko and El Fasher

(1) The width of Musko bridge must be broadened.

(2) From Musko to Shingil Tobaya the route is over sticky clay and runs along wadi. It becomes muddy in the rainy season.

(3) Shingil Tobaya is a big village with many inhabitants, a market center for the area. If centre Route should be selected as the all-weather road, a branch road should be extended to the section between Musko and Shingil Tobaya.

(4) The area between the W. Musko and the W. Darura is extremely sandy. The area for about 5 km beyond the W. Darura has many dunes.

(5) From Alauma to El Fasher the route runs through the plain made by the W. El Ku and the W. Golo, and the area becomes muddy in the rainy season. There are areas of cultivated and arable lands with scattered villages. In order to construct an all-weather road through this section, banking higher than 1.5 m above the plain must be made. The sand which is to be mixed for banking materials, and the crushed rubble for protecting the slope of the bankings, must be transported for a long distance, which would add a considerable sum to the construction cost.

8. Centre Route (B) which goes between Musko and El Fasher

(1) Between Musko and El Fasher the nature of soil is comparatively good.

(2) The vicinity of Melabikki is of heavy sand.

(3) For about 13 km before and after the crossing of the W. Key the soil is clay and the section becomes muddy during the rainy season, this would make it necessary to bring sand from sandy hill areas in order to mix and to build the banking.

(4) Between Abu Zureiga and Kireiga there is an immense dune. The existing road crosses over the dune, and has some steep slopes which, however, can be avoided by taking a round about route.

In this heavy sandy zone no cutting sections must be installed, because a cutting section is liable to be buried by sand in a short time.

Crushed stones, which consist of mixed grains of pebbles, are to be scattered and well rolled, before the road is constructed. The level of road is to be raised 0.5 - 1.0 m above the natural ground level to check the sand from gathering on the surface of road.

(5) The nature of the soil of the plain along the W. Golo is clayish and a dike is to be constructed, with its slope surface below the water-level of flood time being protected by rubble. Between the section from the bridge of the W. Golo to El Fasher there is already a partly constructed bank for an allweather road, but its alignment must be improved and widened.

9. West Route (C) from Merawashei to El Fasher

(1) This route branches from the above route, passes over some khors, crosses the W. Amer at Tom Kitir and goes into Marshing. The nature of soil in this section is comparatively good.

(2) Marshing is a comparatively big village and has an elementary school and a market.

(3) The nature of soil between Marshing and Melemm is excellent.

(4) Melemm is a very big village and has a large market. Suni, which is the only Sudanese summer resort, is within a two and a half hours trip.

(5) The route from Melemm up to the north of J. Kulgi via Sabun and Tarni passes through a hilly district. Soil is good and stones necessary for building, can easily be acquired.

(6) Between the north of J. Kulgi and the plain of W. Golo there extends a sandy waste, which, however, is not so desolate as that of the Centre Route.

(7) It is recommended that a bank should be constructed, through the area extending over the Plain of W. Golo, which is common to other routes.

10. Structure of Road

For road structure, the muddy area necessitates the construction of banks as shown in Fig. 6, and the heavy sandy wastes require structures as shown in Fig. 7. The standard for bridges which cross over Wadi is recommended to be one that consists of prefabricated Reinforced concrete girders of Transportable 6 meter Span. Bridges with a span of 3m, 2m and 1m with drain pipes are recommended for the Khors.

11. Comparison of the 3 Routes

(1) Comparison of Distance

East Route measures 220Km, Centre Route 187Km and West Route 217Km respectively.

Accordingly, Centre Route is the shortest.

(2) Comparison of Construction Costs

The cost of gravelling or paving of each route may be compared as shown in table 2 attached. In brief, in case of gravelling, West Route is least expensive, but, for paving Centre Route is.

Table 2 Cost of construction of the Road between Nyala and El Fasher
(Unit: Sudanese £) (Excluding Overhead Expenses)

	Unit Price £	East Route (A) 220 KM		Centre Route (B) 187 KM		West Route (C) 217 KM	
Earth Work	0.2/m ³	2,430,000 m ³	486,000	1,540,000 m ³	308,000	1,350,000 m ³	270,000
Sub Grade	1.5/m ³	84,000 m ³	126,000	99,000 m ³	148,500	62,000 m ³	93,000
Bridge	300/m	944 m	283,200	940 m	282,000	1,064 m	319,200
Drain	100/spot	134 spot	13,400	98 spot	9,800	134 spot	13,400
Sub Total			908,600		748,300		695,600
Pavement							
Ballast (depth 10 cm)	0.15/m ²	1,540,000 m ²	231,000	1,309,000 m ²	196,400	1,519,000 m ²	227,900
Asphalt (depth 5 cm)	1.0/m ²	1,540,000 m ²	(1,540,000)	1,309,000 m ²	(1,309,000)	1,519,000 m ²	(1,519,000)
Expenses inci- dental to the con- struction work (10%)			114,000 (244,900)		94,500 (205,700)		92,400 (221,500)
TOTAL							
Ballast Pavement			1,253,600		1,039,200		1,015,900
Asphalt Pavement			(2,693,500)		(2,263,000)		(2,436,100)

(3) Conditions along the Routes

The comparison between East Route and Centre Route in the area north of Musko shows that the Centre Route mostly passes through heavy sandy districts and has no agriculture worthy of note. On the other hand East Route enjoys much utility value, for it mostly passes through areas of clayish soil, where many plots of cultivated and arable lands and villages can be seen. East Route is fully available for use during the dry season, but during the rainy season which lasts for four months its use is restricted.

Like the East Route, West Route boasts many inhabitants, and much arable land with cattle and live stock. It has much utility value with Suni near at hand. As most of the West Route has good soil, the sand zone is not so great a consideration this makes possible the construction of wadi crossings with a smaller investment of funds.

On the other hand, Centre Route is of no noticeable benefit to the roadside inhabitants.

However, it is the shortest route connecting Nyala and El Fasher, which makes construction materials more easily available, and its cost much less. If cost is the principal factor, this should lead to a conclusion that the Centre Route is the most suitable for constructing an all-weather-road which is to link Nyala and El Fasher.

Fig. 4 (Refer to the end of the book.)

Fig 6

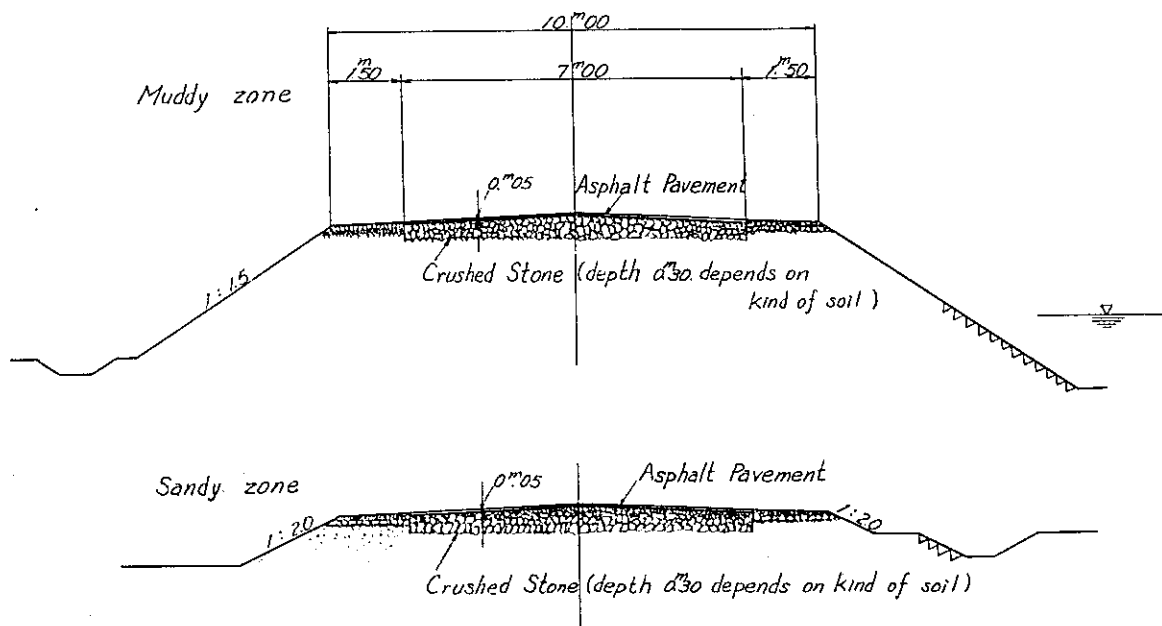
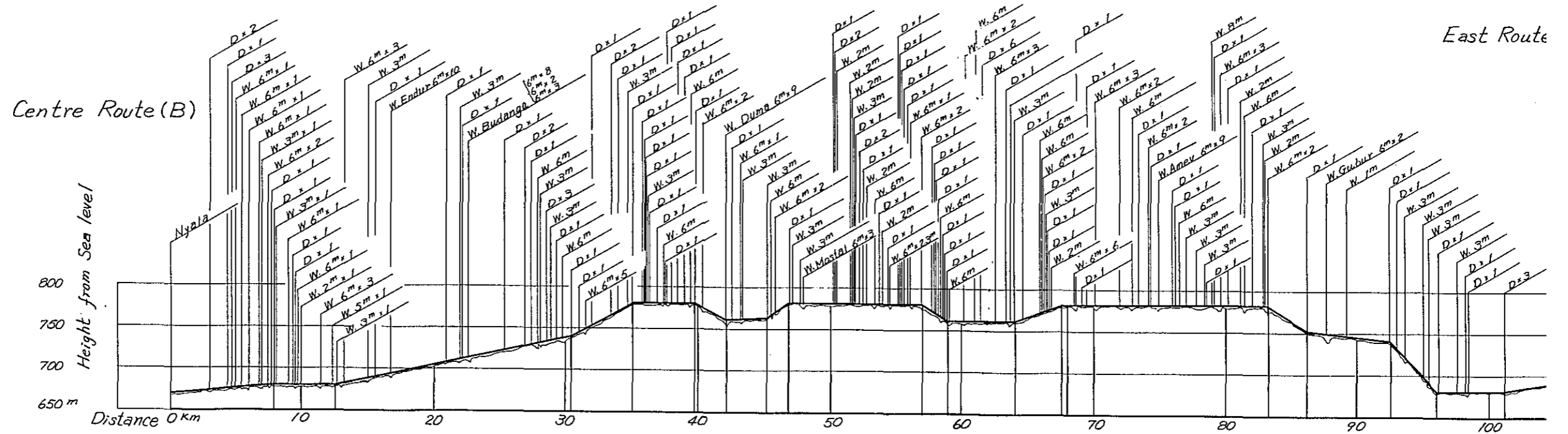
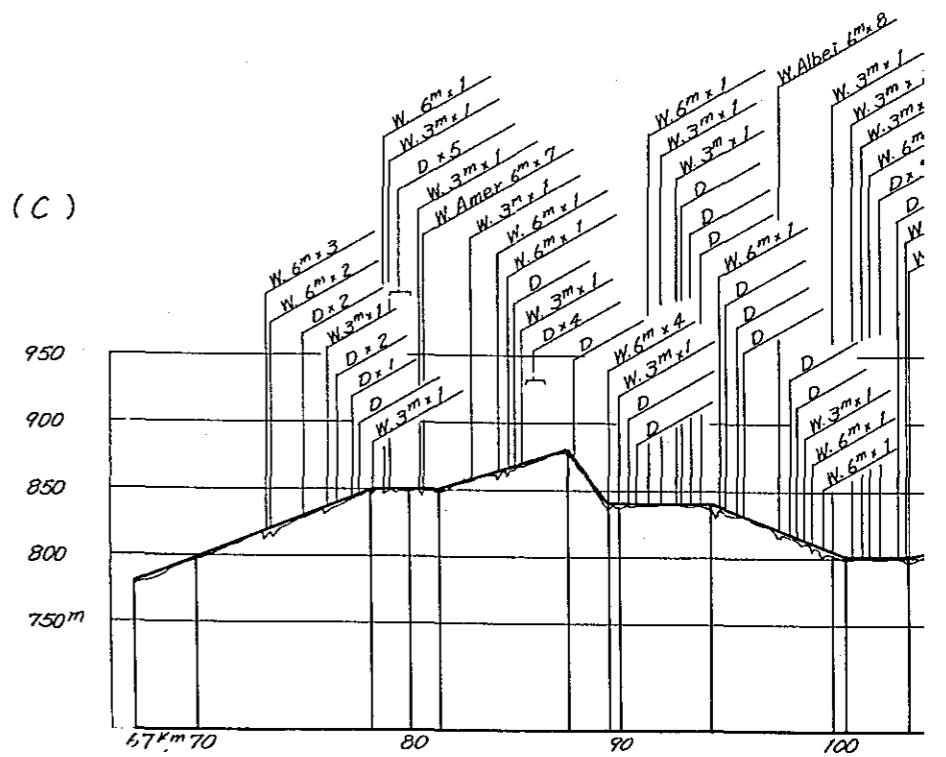


Fig 5 Profile of the Road between Nyala and El Fasher

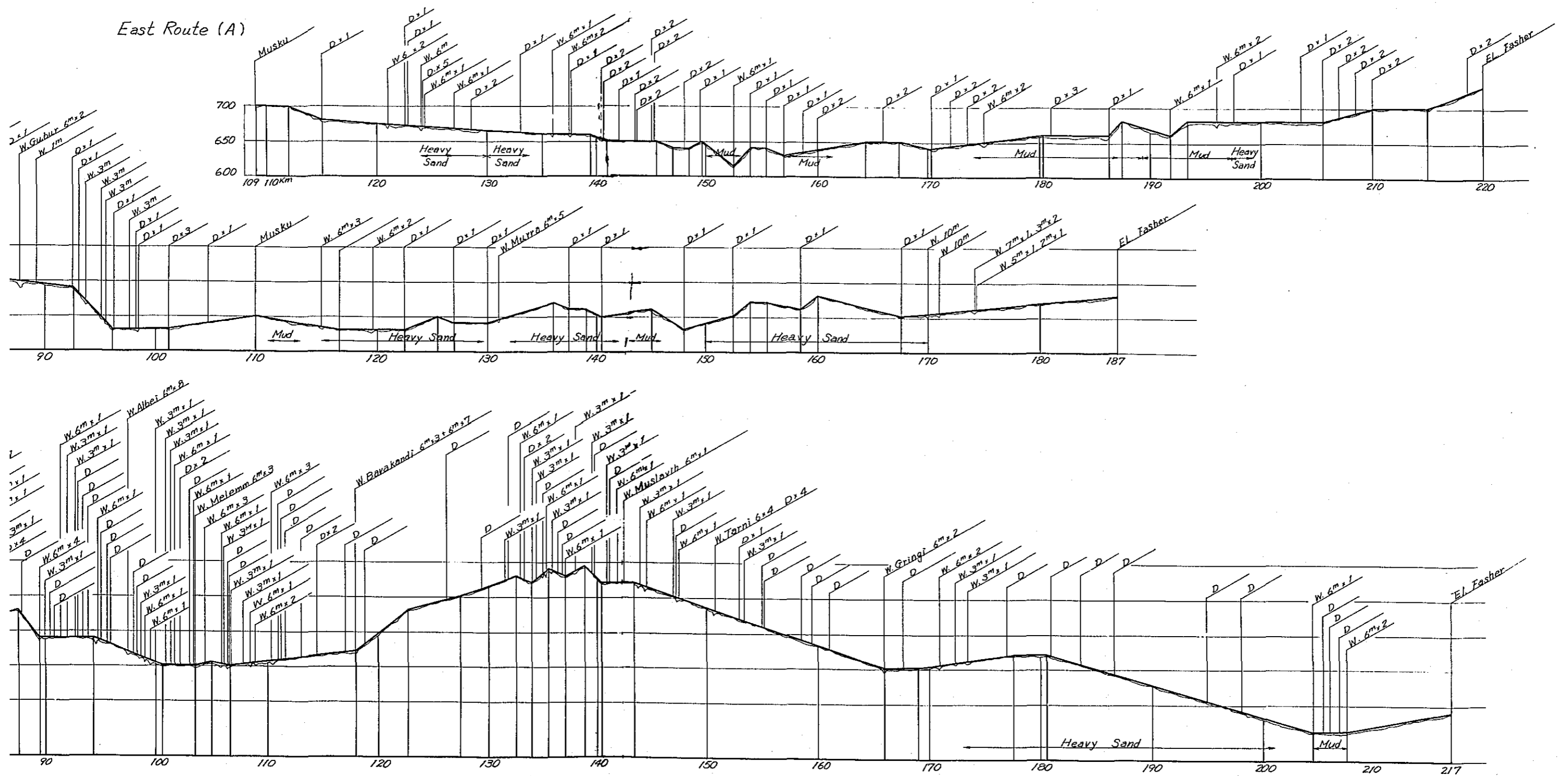


Scale Vertical $\frac{1}{4,000}$
 Horizontal $\frac{1}{250,000}$

West Route (C)



East Route (A)



IV C O N C L U S I O N

In accordance with the results of field investigations we came to the following conclusion:

1. The railroad between Nyala and Geneina

Detailed investigation as to the economic condition prevailing in the area between Nyala and Geneina could not be carried out in this rough survey. However, it is already evident that a stretch of arable land extends all along Wadi Azum and stock breeding is an important industry. Bright economic outlook may be expected as a result of the survey now being conducted jointly by the Sudanese Government and the United Nations for the Jebel Marra development programme. As the project is instigated, great progress can be anticipated in the development of agricultural and livestock industries in that area.

The area is well inhabited all along the Route selected in our survey. In addition, it would be used by seasonal workers coming from Chad to pick cotton, as well as by Mohammedaus pilgrimage. Therefore, from every aspect the route would be of the greatest value.

In order to meet this demand most effectively a railroad would be recommended before a highway as the means of transportation between Nyala and Geneina. Judging from the favorable situation of the new line between Babanusa and Nyala following its construction, it is anticipated that the operation of the newly selected Railway route would promise a profitable business in several years even if it should operate in the red in the beginning.

Further, it may be added that it would be advisable from a political standpoint and also from the view of stabilizing the people's welfare that the present railroad which reaches Nyala should be extended to the border line with Chad.

The survey is the first action to investigate that economic condition in outline, as mentioned already, and the Japanese Government is willing to make further cooperation toward the hope of your country for pushing forward the preceding program, if nay.

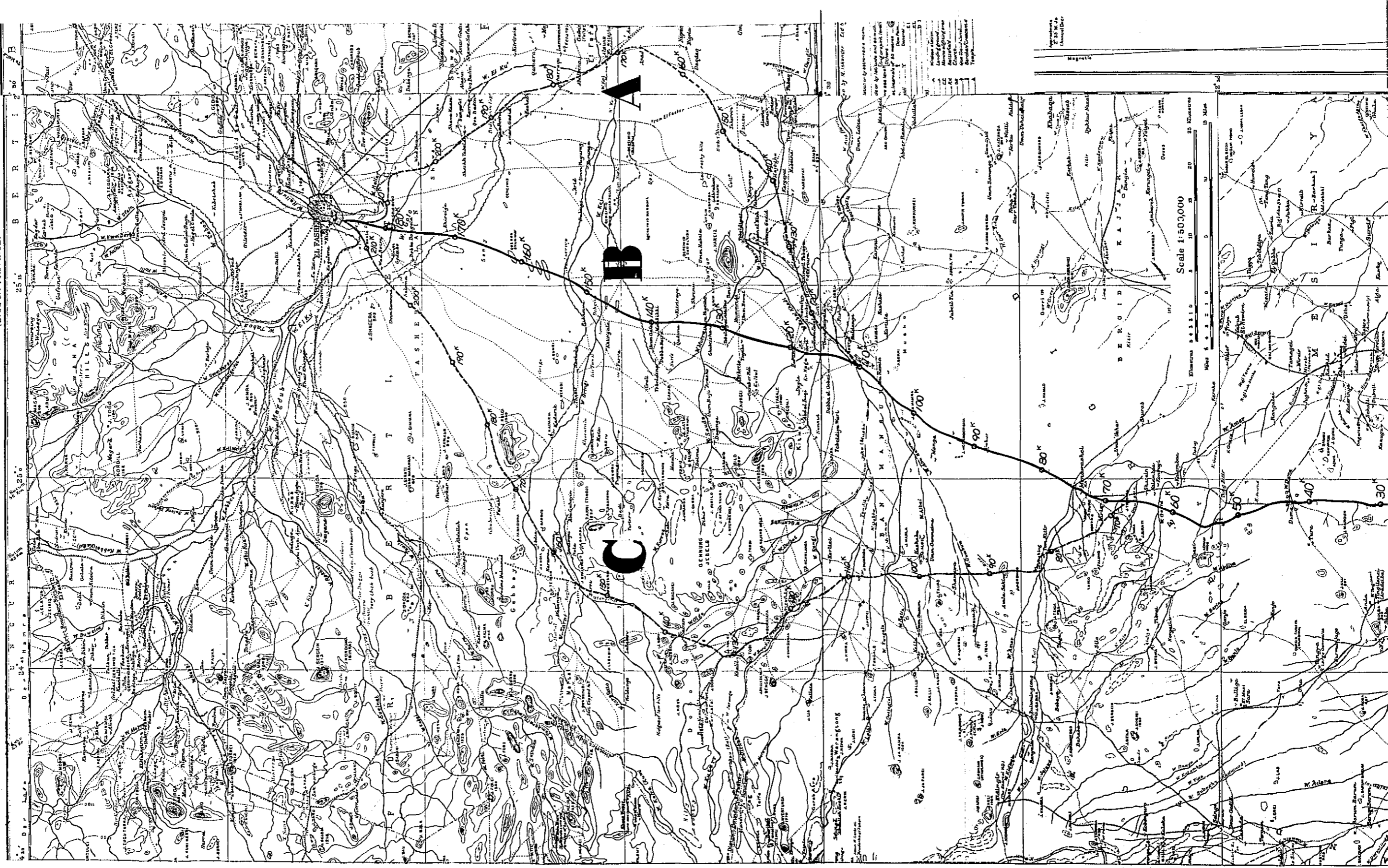
2. The Road between Nyala and El Fasher

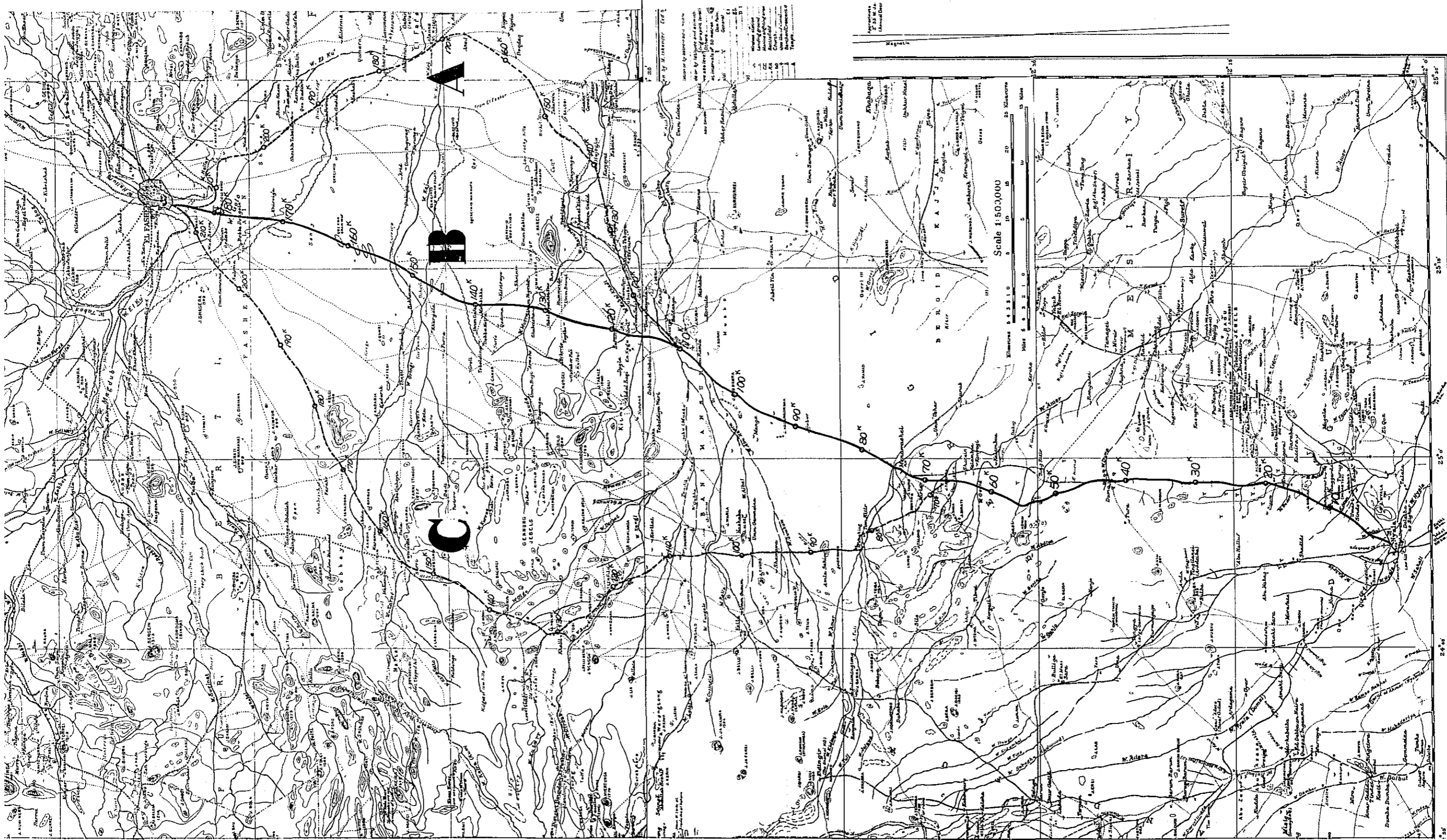
As regards the transportation route between Nyala and El Fasher, 3 routes, namely, the East Route, the Centre Route and the West Route were compared and examined. Accordingly, we came to the conclusion that an All-Weather-Road must be constructed along the

Centre Route.

El Fasher is the capital of Darfur Province and Nyala is the terminal of the existing railroad. These two cities must naturally be linked with the communication route which will be useable throughout the year. Considering the volume of traffic, however, a railroad is not necessary; a road may be enough. However, if the construction of a double track asphalt-paved road cannot be expected at the present because of economic reasons, it may be recommended that, in the beginning, bridges be built with a single track width and the surface of roads be ballast paved. Asphalt-paved roads would run only over the heavy sand Zones. The width of the bridges may later be widened to the width of a double track to cope with the increase of cars, while the asphalt-paved sections may be gradually extended over the worst areas as funds are made available.

Fig. 4 EL FASHER



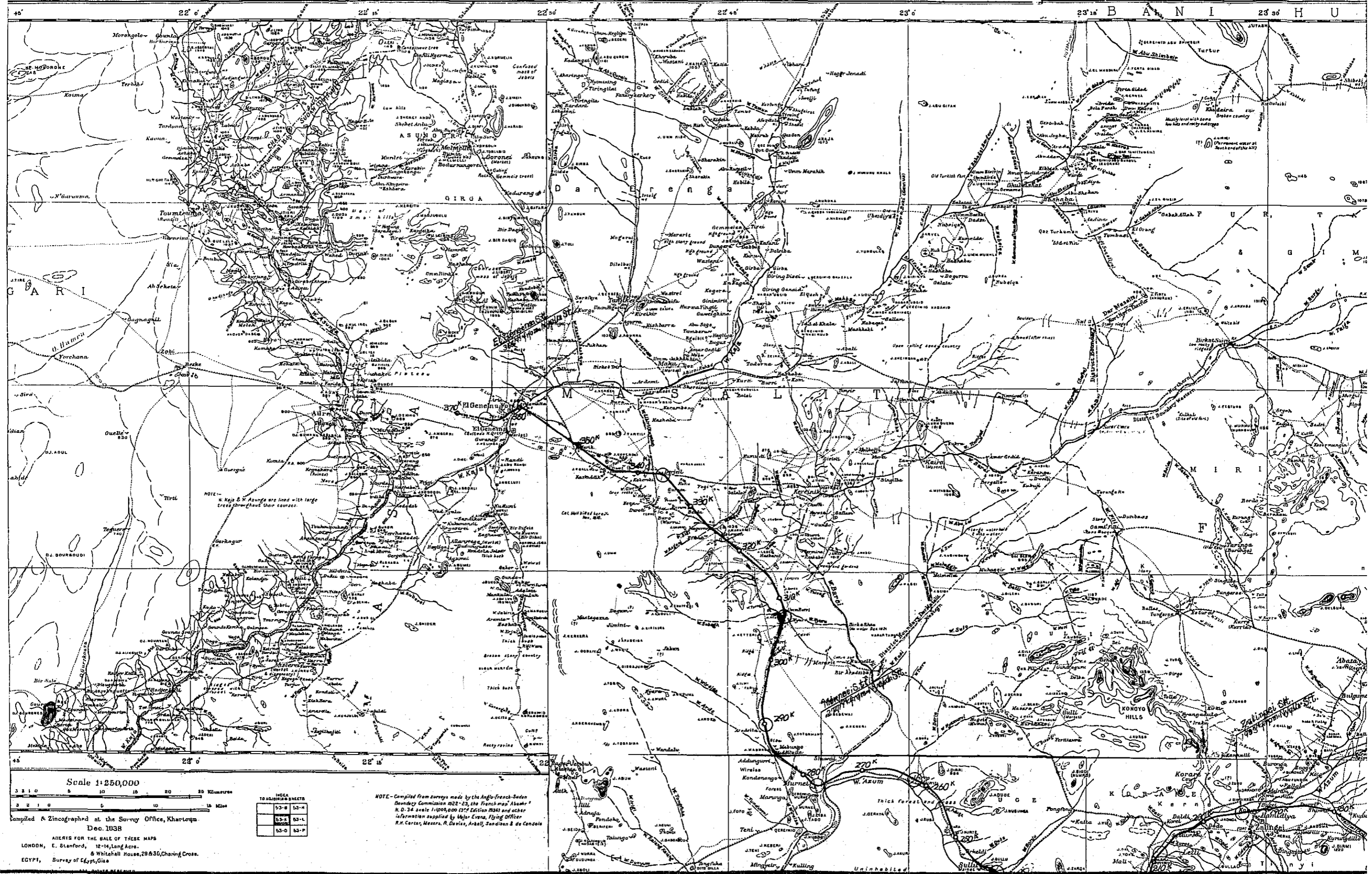


Map by *W. H. H. H. H. H.*
Scale 1:50,000
Magnetic

Scale 1:50,000
Kilometers 0 5 10 15 20
Miles 0 5 10 15 20

Magnetic

25° 30' 25° 25' 25° 20' 25° 15' 25° 10' 25° 5' 25° 0' 24° 55' 24° 50' 24° 45' 24° 40' 24° 35' 24° 30' 24° 25' 24° 20' 24° 15' 24° 10' 24° 5' 24° 0' 23° 55' 23° 50' 23° 45' 23° 40' 23° 35' 23° 30' 23° 25' 23° 20' 23° 15' 23° 10' 23° 5' 23° 0' 22° 55' 22° 50' 22° 45' 22° 40' 22° 35' 22° 30' 22° 25' 22° 20' 22° 15' 22° 10' 22° 5' 22° 0' 21° 55' 21° 50' 21° 45' 21° 40' 21° 35' 21° 30' 21° 25' 21° 20' 21° 15' 21° 10' 21° 5' 21° 0' 20° 55' 20° 50' 20° 45' 20° 40' 20° 35' 20° 30' 20° 25' 20° 20' 20° 15' 20° 10' 20° 5' 20° 0' 19° 55' 19° 50' 19° 45' 19° 40' 19° 35' 19° 30' 19° 25' 19° 20' 19° 15' 19° 10' 19° 5' 19° 0' 18° 55' 18° 50' 18° 45' 18° 40' 18° 35' 18° 30' 18° 25' 18° 20' 18° 15' 18° 10' 18° 5' 18° 0' 17° 55' 17° 50' 17° 45' 17° 40' 17° 35' 17° 30' 17° 25' 17° 20' 17° 15' 17° 10' 17° 5' 17° 0' 16° 55' 16° 50' 16° 45' 16° 40' 16° 35' 16° 30' 16° 25' 16° 20' 16° 15' 16° 10' 16° 5' 16° 0' 15° 55' 15° 50' 15° 45' 15° 40' 15° 35' 15° 30' 15° 25' 15° 20' 15° 15' 15° 10' 15° 5' 15° 0' 14° 55' 14° 50' 14° 45' 14° 40' 14° 35' 14° 30' 14° 25' 14° 20' 14° 15' 14° 10' 14° 5' 14° 0' 13° 55' 13° 50' 13° 45' 13° 40' 13° 35' 13° 30' 13° 25' 13° 20' 13° 15' 13° 10' 13° 5' 13° 0' 12° 55' 12° 50' 12° 45' 12° 40' 12° 35' 12° 30' 12° 25' 12° 20' 12° 15' 12° 10' 12° 5' 12° 0' 11° 55' 11° 50' 11° 45' 11° 40' 11° 35' 11° 30' 11° 25' 11° 20' 11° 15' 11° 10' 11° 5' 11° 0' 10° 55' 10° 50' 10° 45' 10° 40' 10° 35' 10° 30' 10° 25' 10° 20' 10° 15' 10° 10' 10° 5' 10° 0' 9° 55' 9° 50' 9° 45' 9° 40' 9° 35' 9° 30' 9° 25' 9° 20' 9° 15' 9° 10' 9° 5' 9° 0' 8° 55' 8° 50' 8° 45' 8° 40' 8° 35' 8° 30' 8° 25' 8° 20' 8° 15' 8° 10' 8° 5' 8° 0' 7° 55' 7° 50' 7° 45' 7° 40' 7° 35' 7° 30' 7° 25' 7° 20' 7° 15' 7° 10' 7° 5' 7° 0' 6° 55' 6° 50' 6° 45' 6° 40' 6° 35' 6° 30' 6° 25' 6° 20' 6° 15' 6° 10' 6° 5' 6° 0' 5° 55' 5° 50' 5° 45' 5° 40' 5° 35' 5° 30' 5° 25' 5° 20' 5° 15' 5° 10' 5° 5' 5° 0' 4° 55' 4° 50' 4° 45' 4° 40' 4° 35' 4° 30' 4° 25' 4° 20' 4° 15' 4° 10' 4° 5' 4° 0' 3° 55' 3° 50' 3° 45' 3° 40' 3° 35' 3° 30' 3° 25' 3° 20' 3° 15' 3° 10' 3° 5' 3° 0' 2° 55' 2° 50' 2° 45' 2° 40' 2° 35' 2° 30' 2° 25' 2° 20' 2° 15' 2° 10' 2° 5' 2° 0' 1° 55' 1° 50' 1° 45' 1° 40' 1° 35' 1° 30' 1° 25' 1° 20' 1° 15' 1° 10' 1° 5' 1° 0' 0° 55' 0° 50' 0° 45' 0° 40' 0° 35' 0° 30' 0° 25' 0° 20' 0° 15' 0° 10' 0° 5' 0° 0' 0° 55' 0° 50' 0° 45' 0° 40' 0° 35' 0° 30' 0° 25' 0° 20' 0° 15' 0° 10' 0° 5' 0° 0'



Scale 1:250,000

3 5 10 20 Kilometers
 3 5 10 Miles

Compiled & Zincographed at the Survey Office, Khartoum
 Dec. 1938

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SHEET	
53-K	53-L
53-M	53-N
53-O	53-P

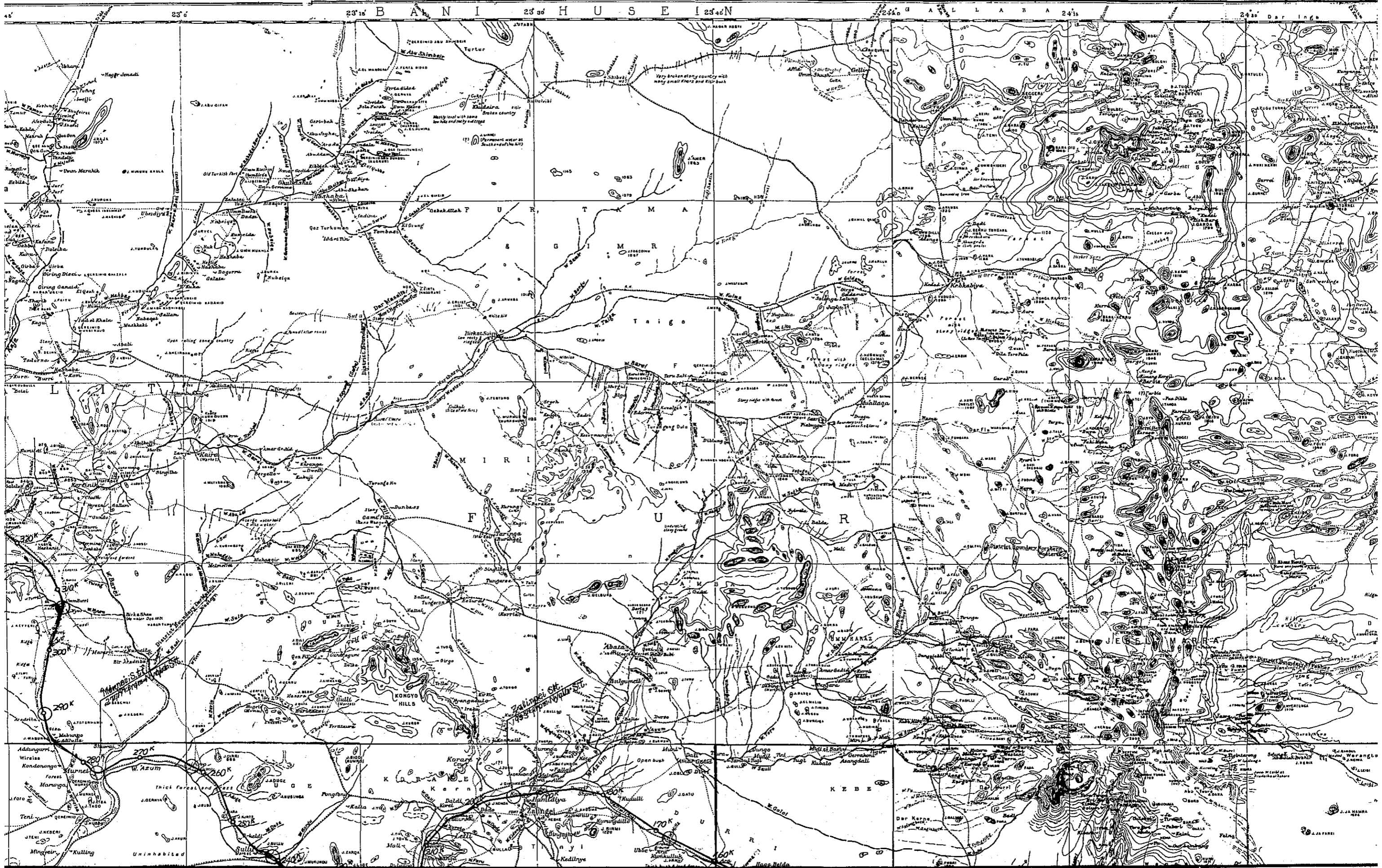
NOTE—Compiled from surveys made by the Anglo-French-Sudan
 Boundary Commission 1922-23, the French map 'Abeir'
 N. O. 34 scale 1:100,000 (1927 Edition 1934) and other
 information supplied by Major Evans, Flying Officer
 R. M. Carter, Messrs. R. Davies, Arkell, Sandison & Co. Cairo

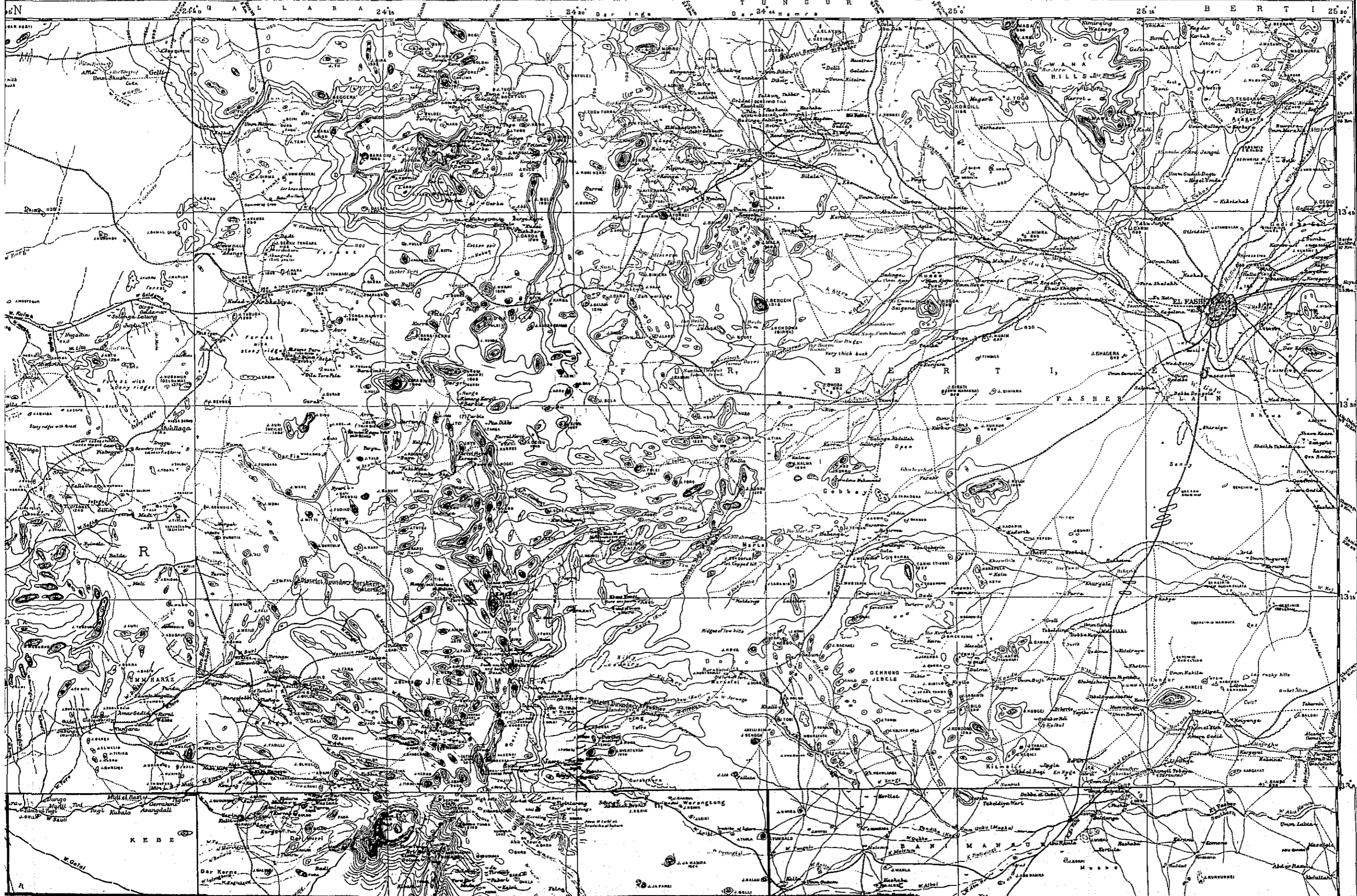
Fig. 2

KEREINIK

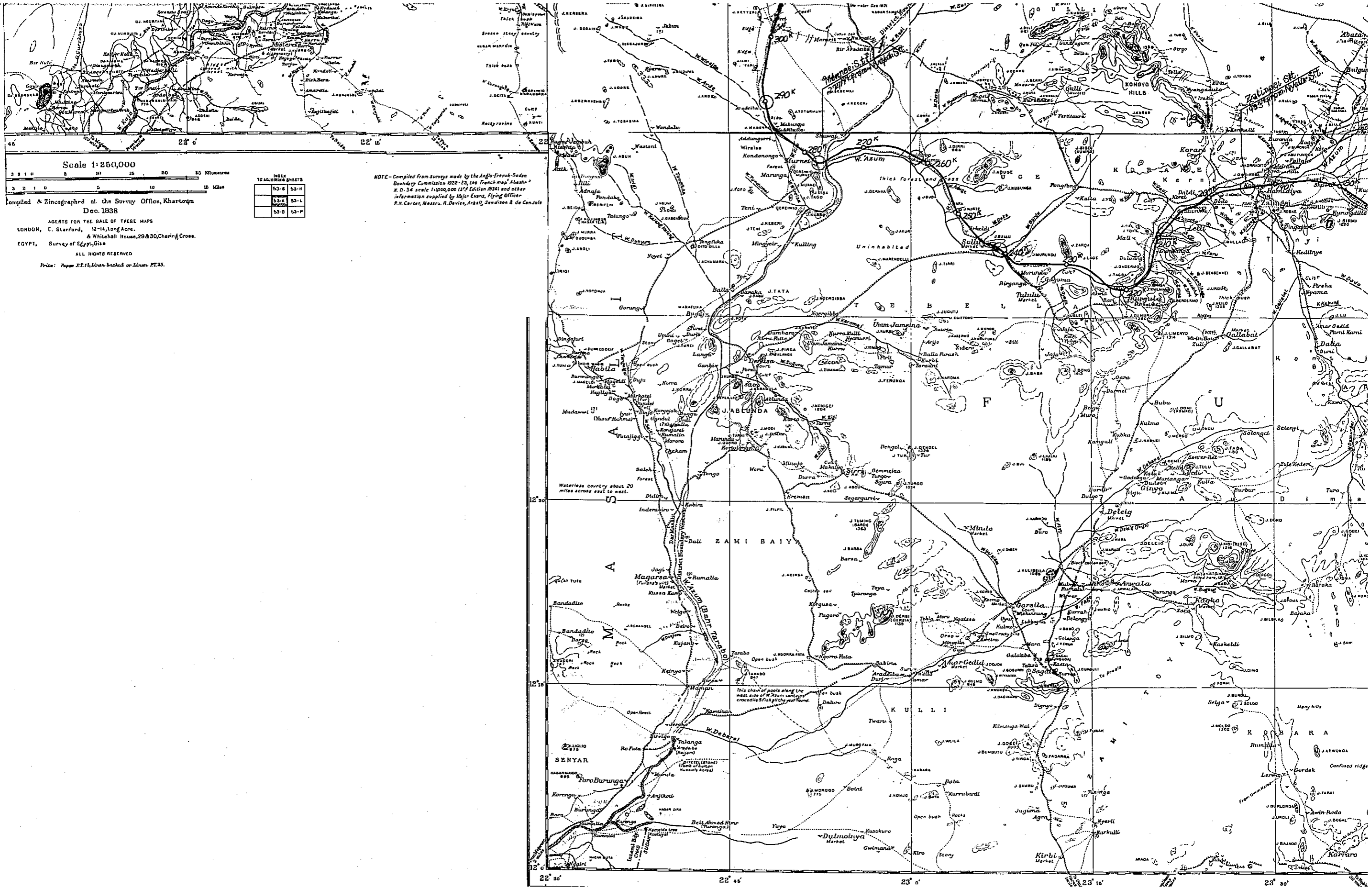
(DARFUR PROVINCE)

SHEET 53-L

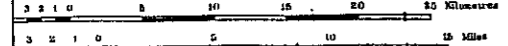




Var. T 55 W. 10m/100ft
(Annual Decrease %)



Scale 1:250,000



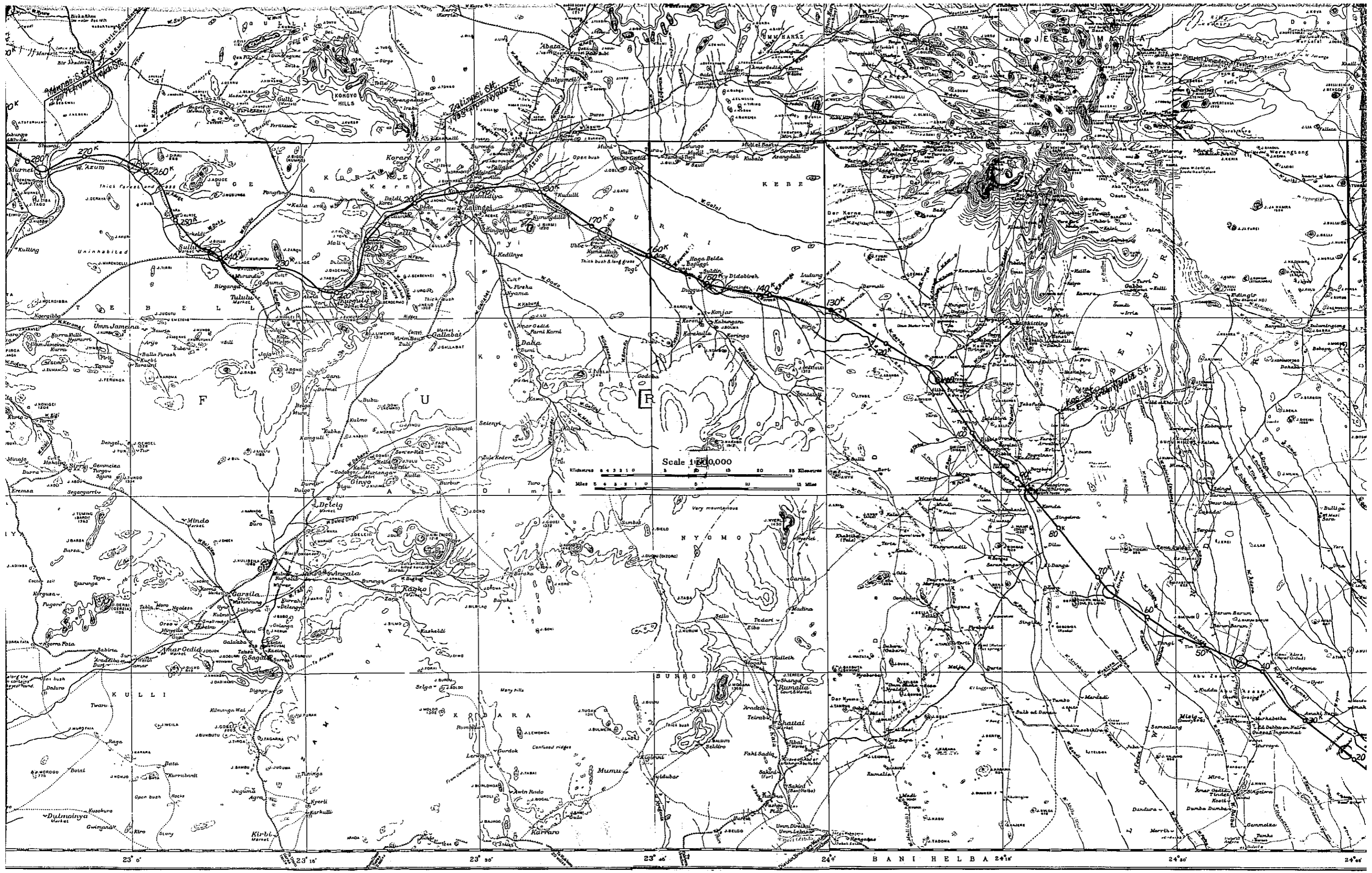
INDEX TO ADJOINING SHEETS	
53-6	53-H
53-N	53-L
53-O	53-P

NOTE—Compiled from surveys made by the Anglo-French-Sudan Boundary Commission 1922-23, the French map *Algerie N. O. 34* scale 1:1,000,000 (1st Edition 1934) and other information supplied by Major Evans, Flying Officer R. H. Carter, Messrs. H. Davis, Arkell, Swindson & de Candolle

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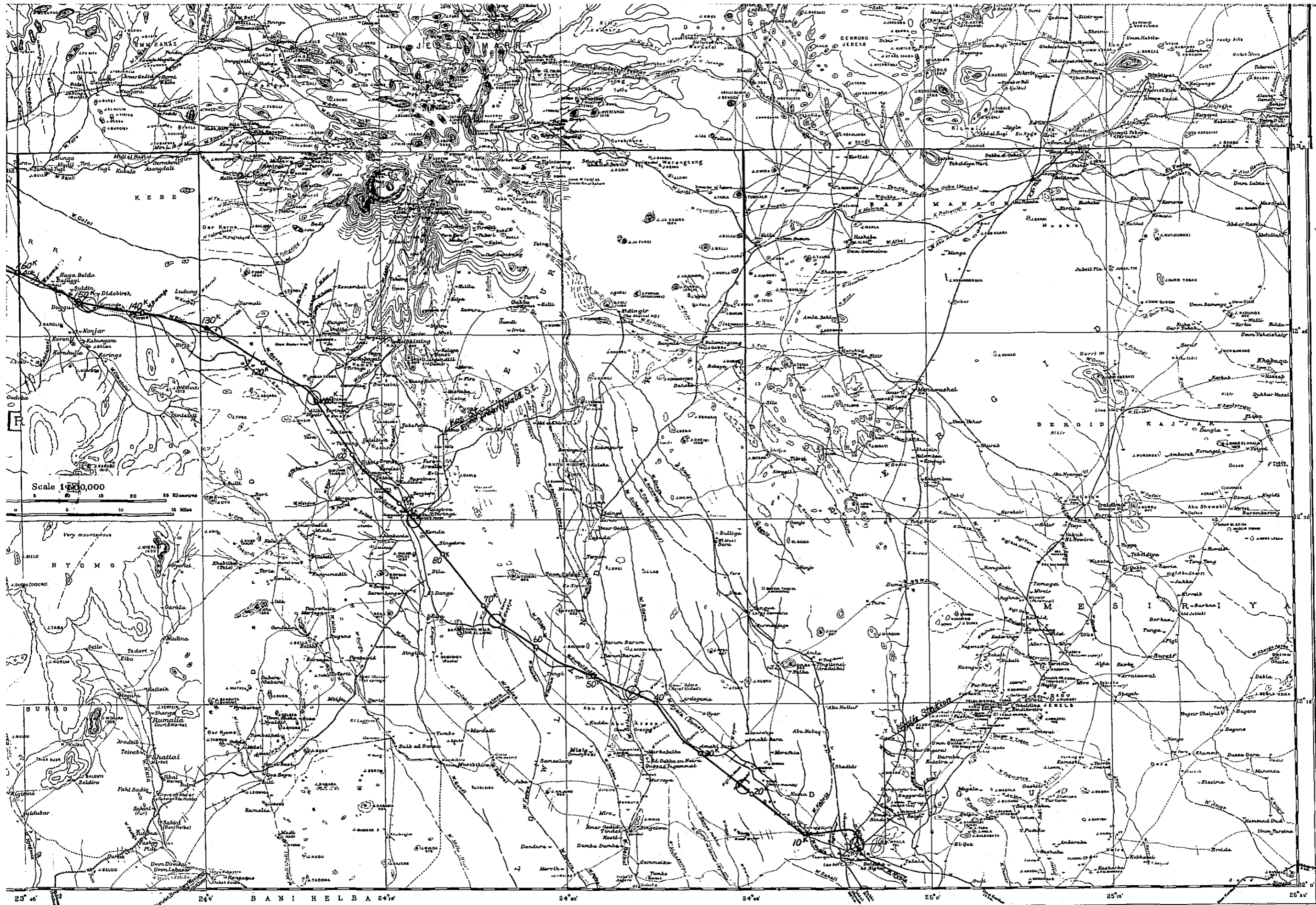
This chain of pools along the west side of W. Debari contains crocodiles & fish at the wet season

Waterless country about 20 miles across east to west.



Scale 1:500,000
Kilometers 0 10 20 30 40 50
Miles 0 10 20 30 40 50

23° 0' 23° 15' 23° 30' 23° 45' 24° 0' 24° 15' 24° 30' 24° 45'



Scale 1:500,000
0 5 10 15 20 25 Kilometers
0 5 10 15 Miles

Approximate Variation
7.33 W. Jan. 1964
(Annual Decrease 6)

23° 26' 24° 24° 24° 25° 26° 26°

BANI HELBA 24°

