

## CHAPTER V

### THE MIDDLE EAST

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#### SECTION 1. SURVEY ORGANIZATION AND NARRATIVE

##### Early Survey activities in the Middle East

Early in 1940 a Director of Survey was appointed, together with a small Directorate staff, to take up duty with the Military Headquarters in Cairo. Colonel R. L. Brown went out in February, with personnel based on the war establishment for an Army Survey Directorate. Two survey units followed soon afterwards. The first of these, 512 (Army) Field Survey Company R.E. was of similar type to that which had accompanied the B.E.F. to France in September, 1939. It consisted of a mobile echelon of four topographical sections for field survey work, and an immobile echelon consisting of sections for drawing, photography, map reproduction and printing. The other unit was 2 Field Survey Depot R.E., for holding and issuing bulk map stocks. It was of the original standard type of depot with an establishment of one officer and 18 other ranks. These units arrived in Cairo about the middle of March. The Director of Survey soon realized that 512 Field Survey Company as it stood did not possess sufficient potential to deal with the map production programmes which it would have to undertake, and he therefore asked for an extra five drawing sections. By October, 1940, its establishment was increased to about 14 officers and 350 other ranks. The Survey Departments in Egypt and Palestine were also both called on to undertake a considerable amount of reproduction work on an agency basis.

The topographical sections of 512 Company were at first employed on special survey work for the Engineer-in-Chief, including surveys for base lay-out, and also on the fixation of numerous anti-aircraft and coast defence gun positions in Alexandria and Port Said and in Palestine. The immobile echelon, while in Cairo, was engaged on a variety of mapping tasks including the preparation of skeleton 1/M air maps and the reproduction of 1/200,000 maps of Turkey from the Turkish originals.

### **Mapping Problems**

The entry of Italy into the war on 10th June, 1940, made it practically certain that hostilities in Africa would not be long delayed, both in Libya and also in the Italian East African colonies and Abyssinia. The responsibilities of the Director of Survey for carrying out large programmes of mapping over wide areas were intensified. The available map series published by the War Office were neither extensive nor up to date. It was necessary to obtain record copies of the best and most up-to-date maps of the areas involved from a variety of sources and reproduce them locally, overprinting the military grid on them. There was also a great amount of research work to be done in connection with investigations into the local triangulation systems, and the preparation of trig lists for use by field surveyors including artillery survey regiments. Arrangements had to be made with the R.A.F. for air photography of selected areas, not only for the revision of existing maps, but also for the preparation of new ones. With such a wide field for possible operations, not only in Africa, but also in the Balkans, Palestine and Syria, Iraq and Persia, there was a great deal to be done, not much time to complete it, and a definite shortage of survey personnel and equipment.

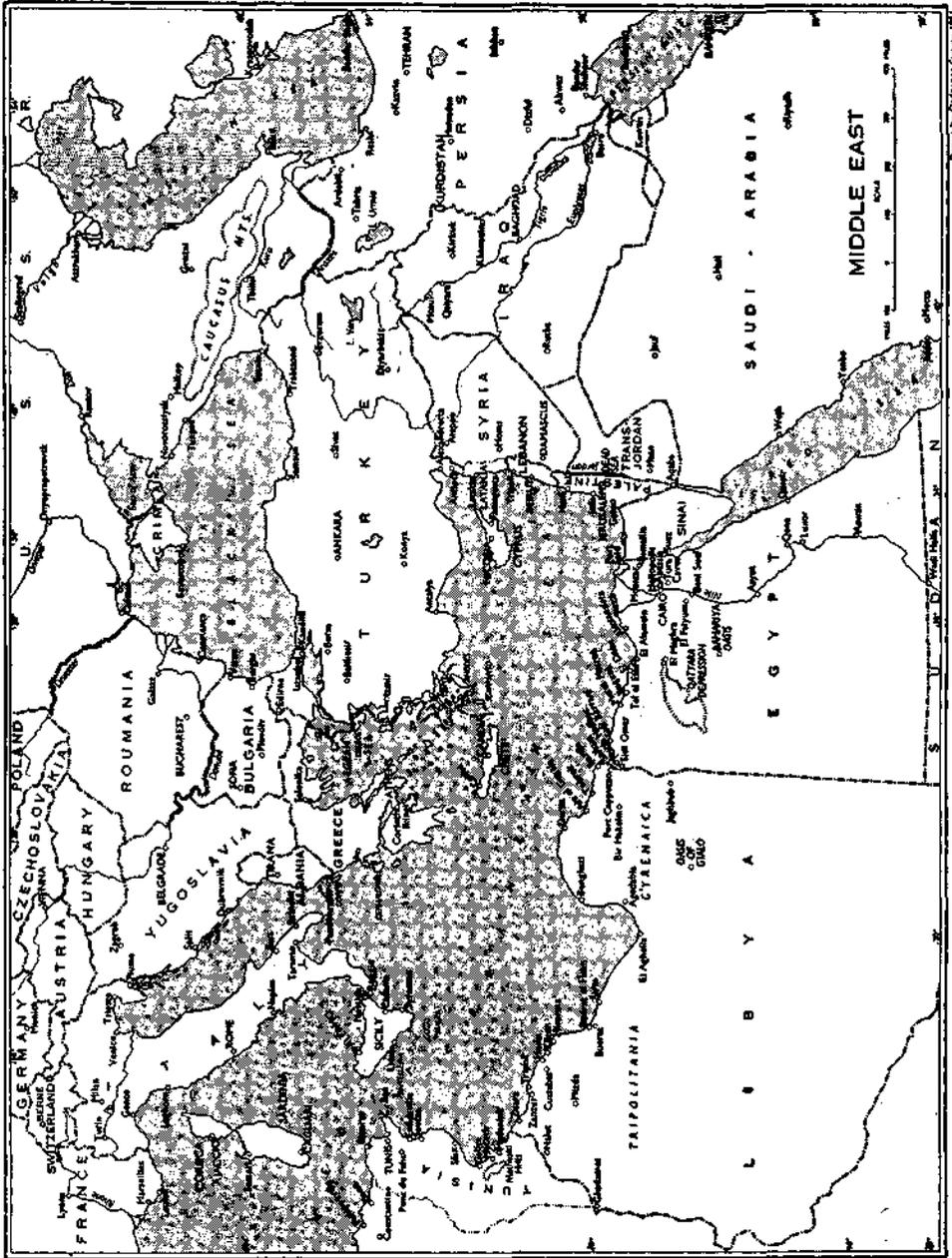
### **Survey contacts with the Desert Force**

Headquarters of the British Troops in Egypt (B.T.E.) was established in Cairo. G.H.Q. Middle East, which was a separate headquarters originally formed for planning, was also in Cairo. This latter rapidly grew in numbers and in the scope of its responsibilities. In the early days H.Q. B.T.E. exercised the immediate command and control of all troops in Egypt including the Western Desert Force, and an A.D. Survey was therefore appointed, with a Corps Directorate, to do duty with this H.Q. An officer (Captain) was detached from the Survey Directorate for liaison duty with the Desert Force. The mobile echelon of 512 Field Survey Company was placed under command of H.Q. B.T.E., and so came under the technical control of the A.D. Survey with that formation. At an early opportunity field observations were made to effect a junction between the Egyptian and Italian triangulations in Cyrenaica by intersecting Italian trig points across the frontier. In August the mobile echelon carried out field work for an extension of the Survey of Egypt 1/25,000 series in the Mersa Matruh area by air survey methods. Concurrently, a 1/12,500 defences map of Matruh was produced, and several subsidiary points were established for use by R.A. survey parties in the Matruh area.

### **The Italian advance to Sidi Barrani**

By 2nd August, 1940, the Italians had massed their forces on the frontier, and on 14th September they crossed into Egypt and advanced to Sidi Barrani, where they dug in. Apart from air action and patrol activity there remained

SKETCH MAP 3



nearly three months before any major operations were to begin in the Western Desert. During that period, however, many events occurred which were to affect future policy and which involved the Survey Service in ever-widening activities.

### **The strategic situation in the Middle East (late 1940)**

Late in September, General de Gaulle made his abortive attempt to persuade the French in Dakar to throw in their lot with the Allies. It then became clear that under Vichy influence, French co-operation in North Africa and in Syria was unlikely. They might, in fact, be actively hostile. British Somaliland had been evacuated, and the small British forces in the Sudan and in East Africa were engaged in patrol activities facing greatly superior Italian forces. German troops had entered Roumania and Italian forces crossed the frontier from Albania into Greece early in November. Roumania joined the Axis on the 23rd of that month, and small numbers of British troops, including R.A.F. units, were sent to Greece.

All these events involved the Survey Directorate in an intensive and urgent programme of map production, in anticipation of any emergency situation which might arise.

### **First British offensive in the Western Desert (December, 1940)**

The first British offensive in the Western Desert opened on 9th December and by the 14th the Italians were back over the frontier in Cyrenaica. This unexpectedly quick success was exploited to such purpose that, by 7th February, Benghazi had been captured and El Agheila occupied. The rapid advance threw a great strain on map supply resources which, at that time, had not been fully developed according to subsequent standards.

### **Capture of Italian mapping material**

Together with the capture of thousands of prisoners, many Italian maps were obtained, an item of great importance. These maps were sent back to Cairo and were rapidly reproduced, with the addition of the British military grid. Stocks were then sent forward to the fighting troops with the least possible delay.

One of the most interesting captures was one isolated copy of an Italian 1/25,000 map of Tobruk. Large scale maps of the Tobruk defences were produced from it, not only for our own use, but unfortunately, as events turned out, for German use as well. The Germans captured a copy of the British reproduction and, in turn, copied it themselves, being apparently unaware up till then of the existence of an Italian map of Tobruk on that scale.

### **Triangulation in Western Egypt and Libya**

The only survey unit which accompanied the Desert Force during this first campaign was the mobile echelon of 512 Field Survey Company. After the move into Cyrenaica, the topographical sections ran a chain of triangulation from Egyptian trig stations to connect up with the Italian triangulation system. Subsidiary points were fixed for use by R.A. survey parties in the attack on Bardia.

Much data concerning the Italian triangulations were captured and made use of by these topographical sections, and this was sent back to Cairo for amendment



of existing trig lists and the preparation of new ones. As our forces moved west to Benghazi the topographical sections ran chains of triangulation to establish a relation between the two different Italian systems which had come to light after examination of captured documents, and to serve as control for air photography. There was no mobile printing equipment available to operate with the Desert Force during this first campaign. All map printing had to be done back in Cairo.

#### **514 Field Survey Company R.E. arrives in Middle East and moves south to Eritrea**

514 (Corps) Field Survey Company reached the Middle East from the United Kingdom during the winter of 1940-41 and was sent south to Khartoum. On arrival at Khartoum it was engaged in many tasks concerned with the planning of operations against the Italians in Eritrea. During this preparatory period, quick reconnaissance surveys were carried out for the Chief Engineer, extra fixes were observed to help the R.A.F. use the existing inaccurate maps, and triangulation was undertaken to form a base from which to carry forward a control during the advance towards Keren. Much special map production and printing was done on the unit's mobile equipment for planning and for the actual operations. When the advance began, the movement was so rapid that the carrying forward of a trig control could not keep pace with it. At Keren, triangulation was based on captured Italian data to cover our own gun positions, and points were fixed in the enemy or target area.

#### **Operations in Italian East Africa and Greece (See also Chapters VI and XII.)**

The British offensive against Italian Somaliland and Abyssinia was opened by the crossing of the R. Juba on 20th February, 1941. Although these operations came under the general strategical direction of G.H.Q. Middle East, the actual survey and mapping arrangements were controlled by Colonel M. Hotine (D.D. Survey East African Force). Abyssinia was entered on 7th March, and success was so rapid that Addis Ababa, the capital, was occupied on 5th April. This first week of April was one of mixed successes and misfortunes in the Middle East. Asmara (Eritrea) was taken on the 1st, but on the 3rd an enemy counter-offensive in Libya forced the British to evacuate Benghazi and begin their retreat back to Egypt. On the 6th, German forces invaded Yugoslavia and in conjunction with the Italians operating from Albania, marched into Greece. To meet this threat, and to assist the Greek Army, an Expeditionary Force was hastily assembled in Egypt and sent over to Greece. Colonel Hotine, having been withdrawn from East Africa, accompanied the force as D.D. Survey with a small survey directorate. The units placed at his disposal were the headquarters and two sections of the mobile echelon of 512 Field Survey Company, 517 (Corps) Field Survey Company, which had shortly before arrived from the United Kingdom, and 9 Field Survey Depot, which had just been formed in the Middle East theatre. Of the above, only the topographical sections of 512 Company and 517 Company (less its printing equipment) reached Greece together with the Survey Directorate and 9 Depot. The A.F. G 1098 stores of 517 Company, for its printing and drawing sections, were embarked on a separate convoy and were lost.

A large portion of 9 Field Survey Depot was taken prisoner, together with

personnel from the Survey Directorate and from the topographical sections of 512 and 517 Companies. The shipment of map stocks from Egypt to Greece presented many difficulties. The first problem was to obtain shipping space against the competition of other urgent commodities. It was then necessary to ensure that when the maps reached Greece they were delivered safely to those requiring them. As on so many subsequent occasions it was found essential to have each consignment accompanied by a conducting officer, who saw the maps through to their journey's end.

#### **Iraq and Syria in the spring of 1941** (*See also* Chapter VII—Persia and Iraq.)

With the Germans established in the Balkans and the French Vichy Government definitely hostile, there was cause for anxiety about Syria and the Lebanon, Palestine and Cyprus, Iraq and Persia as possible stepping stones for a German drive to the east. Trouble had already occurred in Iraq, where enemy influence had persuaded a pro-German element to stage a rising on 11th April, 1941. This necessitated the despatch of an Expeditionary Force from India to restore the situation, and it was not until the end of May that the rebels were rounded up. By that date it was clear that there was strong Vichy influence in Syria, and on 8th June an allied force crossed the frontier from Palestine into Syria. A survey officer had been sent up into Palestine during January for liaison duty with the headquarters of the British Forces in Palestine (later the British Ninth Army), and to establish working relations with the Palestine Survey Department. During the operations in Syria an officer was also attached to the Australian Division in order to obtain early access to survey records in Damascus and Beirut. He was able to assist in map distribution, examination of air photos and the correlation of special map demands.

#### **Survey organization in the Middle East (June, 1941)**

At the end of June, 1941, the Survey organization in the Middle East was as follows:—

##### **(a) SURVEY DIRECTORATES**

###### *G.H.Q. Middle East.*

Officially this was on the establishment laid down for an army, but frequent representations had been made that it was inadequate. To ease the situation most of the officers who had been serving with the East African Directorate were moved to G.H.Q. at the beginning of June, by which date the campaign in Abyssinia was to all intents and purposes over. The Directorate was then reorganized into four main branches:—

- (i) Administration and Stores.
- (ii) Map Records and Production.
- (iii) Triangulation Control and Air Surveys.
- (iv) Map Distribution.

*East Africa.* With the removal of the Directorate staff to the Middle East the remaining functions of this Survey Directorate were exercised by the East African Survey Group which was strong in officers. (*See* Chapter VI.)

*Palestine and Trans-Jordan.* This was originally a skeleton Directorate consisting of one D.A.D. Survey and two clerks. Temporary reinforce-

ment for the operations in Syria proved unsatisfactory. This was now expanded to an Army Survey Directorate serving the Ninth Army, so as to place the whole of this area (including Syria and later Cyprus) on a sound basis.

*Western Desert.* A standard Corps Survey Directorate served the needs of this force.

(b) SURVEY UNITS

*G.H.Q. Troops.*

512 (Army) Field Survey Company R.E. (less detachments).

517 (Corps) Field Survey Company R.E. (less detachments under command Desert Force).

2 Field Survey Depot R.E. (less detachments at El Daba under the control of A.D. Survey Western Desert).

11 Field Survey Depot R.E. (Stores).

(The South African Survey Company was expected to arrive shortly in the Middle East from East Africa.)

(512 Company, the main base production unit, was located on the edge of Heliopolis airfield. This was considered too vulnerable, and arrangements were made for it to be moved to some large caves at Tura, about six miles south-east of Cairo. It was proposed also to move the Map Record and Production Sections from the G.H.Q. Survey Directorate to Tura, together with Nos. 2 and 11 Depots. To deal with the quick revision of maps before urgent reprints were undertaken, a special Revision Group was formed in 512 Company. This group worked in close touch with the R.A.F. Photo Reconnaissance unit which was taking the photographs, and with the Air Photo Interpretation Section (A.P.I.S.) which was controlled by the Intelligence Branch at G.H.Q. This close co-operation between Survey and A.P.I.S. at all the major formation headquarters in all theatres was a necessary and important feature. It concerned not only the revision of topographical detail on the face of the map, but also the preparation of defence overprints, the fixation of enemy gun positions and other defence works, and other items which required expert interpretation and treatment by technical survey methods for determining position with reference to the map grid.)

*East Africa.*

The East African Survey Company, the West African Survey Company, and the Southern Rhodesian Survey Company were organized as the East African Survey Group. There was also a detachment of reproduction tradesmen with printing equipment from 512 Field Survey Company R.E. The West African Survey Company was at this time under orders to return to West Africa.

*Palestine, etc.*

The 2/1 Australian (Corps) Field Survey Company was operating in Palestine, though not under command of the British Military H.Q. there.

No. 9 Field Survey Depot, which had been in Greece and had lost many of its numbers, was reforming, mainly from personnel enlisted locally.

### *Western Desert.*

514 (Corps) Field Survey Company R.E. (less detachments) was at Matruh carrying out large scale surveys. One printing section and details of 514 Field Survey Company, plus one printing and drawing section of 517 Field Survey Company, were at the Alexandria drawing office. Two topographical sections of the mobile echelon of 512 Field Survey Company were in the El Alamein area engaged in topographical surveys of that area. The sections were later transferred to 517 Field Survey Company to make the latter up to strength for its move to Palestine.

The following units were notified as being ready to leave the United Kingdom for the Middle East, but were delayed owing to convoy space being limited:—

13 (Corps) Field Survey Company R.E.

519 (Corps) Field Survey Company R.E.

19 Field Survey Company R.E. (Recently in Iceland.)

(519 Field Survey Company never went to the Middle East. It remained in the United Kingdom until operation "Overlord," when it crossed over to France with Second Army.)

At the time of the Greek campaign, there was a great shortage of survey units. It was necessary, therefore, to form civil establishments, using locally recruited personnel, and equipped with locally purchased or constructed plant. The following organizations were therefore set up, and were capable of rapid drawing and the production of wet plate negatives. They were mainly of use for the reproduction in colours of captured maps or record copies. The number of nationalities represented amongst the personnel was so varied that notices had sometimes to be written up in nine or ten different languages!

*Choubra* (Cairo). This was supervised by an Austrian, with an Armenian deputy assisted by British personnel from 512 Field Survey Company.

*Alexandria drawing office.* Supervised by 514 Field Survey Company under the control of A.D. Survey Desert Force. Printing was carried out by detachments from 514 and 517 Field Survey Companies.

### (c) MAP DISTRIBUTION

The holding and issuing of maps was carried out by a number of dispersed map depots organized and controlled as under:—

(a) *Under G.H.Q. control and manned by personnel of No. 2 Field Survey Depot:—*

Base Map Depot at Abbassia (Cairo). This carried stocks of all maps in use in the theatre. It took delivery of all maps printed under G.H.Q. arrangements, and distributed in bulk to sub-depots. Detailed issues were made to G.H.Q. troops.

G.H.Q. sub-depot. This carried small stocks for issue to branches and staffs at G.H.Q.

Moascar (Canal) sub-depot. This split the stocks with the Base Map Depot as well as providing for troops in the Canal Area.

Alexandria sub-depot. For holding reserve stocks of the Western Desert and Delta areas for the Desert Force and B.T.E.

(b) *Under control of A.D. Survey Western Desert.*

(i) El Daba sub-depot, which held the main stocks for the Desert Force.

(ii) Forward Map Depots at Bagush and Matruh.

(iii) Mobile map distribution unit operating with forward troops.

(c) *Under control of D.D. Survey Palestine and Trans-Jordan.*

- (i) Main Depot at Jerusalem.
- (ii) Sub-depots at Gaza and Tel Aviv.
- (iii) Forward Map Depot at Nazareth, which later moved into Syria.

#### **Arrival of South African Survey Company from East Africa (See also Chapter XIII, Section 3.)**

A valuable addition to the Survey strength during July was the arrival of the South African Survey Company from East Africa. It was assigned to G.H.Q. Survey Troops, and many of its field sections were detached for duty elsewhere. One section was sent to the Western Desert for the survey of forward desert tracks, one was employed on surveys of the defences in the Delta area, and two sections went to the El Alamein area to carry out 1/50,000 mapping. In view of the decisive battle which took place there at a later date, the Director of Survey's decision to undertake this work proved to be a particularly happy example of intelligent forecasting.

#### **Arrival of 60 Squadron South African Air Force**

Another important arrival in July, 1941, was No. 60 Squadron of the South African Air Force (S.A.A.F.) which also came from East Africa, and was to play such a valuable role in the production of air photographs for mapping purposes. On arrival, it was equipped with a small number of Glen Martin Aircraft. This unit was to form part of the Air Survey Photographic unit for the Middle East theatre, the remainder of the unit being provided by the R.A.F. Shortage of suitable aircraft, cameras and other equipment necessary for the production of the special photography required for mapping purposes was to hamper their activities for a long time and seriously affect the mapping programmes.

#### **Survey units in Palestine**

517 Field Survey Company, after being re-equipped and made up to strength, was transferred to Palestine during July, 1941. Policy agreement had now been reached regarding the status of the Australian Survey Company. Although corps troops, it was agreed that the unit would come under the control of the D.D. Survey in Palestine subject to the requirements of the Australian Corps having priority.

#### **Mapping projects in the summer of 1941**

Map production and printing was continuing with ever-increasing momentum, and included series covering Egypt, the Western Desert, Cyrenaica, Palestine and Syria, Turkey, Iraq, Persia, Cyprus, Trans-Jordan, and East Africa. Ground and control surveys were in progress for checking existing triangulations and trig lists, and for providing new control for air survey mapping in the Western Desert, Palestine, Sinai, Syria, the El Alamein area, and the Delta.

#### **Increases in Survey organization**

In August, the G.H.Q. Directorate establishment was increased by five officers, including one D.A.D. Survey (Major). A new Corps Survey Directorate arrived from the United Kingdom for duty with 10 Corps, and one officer

was appointed as Survey representative on the Commission of Control in Syria. Also during this month the advanced party of 13 (Corps) Field Survey Company with the unit transport arrived from the United Kingdom, the remainder of this unit not reaching Egypt until a year later. The 36th New Zealand Survey Battery R.A., which was strong in trained surveyors, was loaned from R.A. control for topographical work under D. Survey G.H.Q.

### **Survey Directorates for Eighth and Ninth Armies**

Important changes took place in the organization of the Middle East Forces during September, 1941. The Western Desert Force became Eighth Army, and a modified Army Survey Directorate of one A.D. Survey (Lieutenant-Colonel H. S. Francis), one D.A.D. Survey and one Captain was assigned to Army H.Q. There was no Survey representation with H.Q. 13 Corps in Eighth Army. In Palestine, the Survey Directorate of the Palestine and Trans-Jordan Force H.Q. was transferred intact to Ninth Army with Colonel A. Prain as D.D. Survey. 10 Corps moved to Palestine without a Survey Directorate, the personnel having been transferred to H.Q. B.T.E. These changes conformed to the newly accepted policy that where a field force was operating under an Army H.Q., Survey representation in the form of directorates and units would normally be concentrated at army level, and not decentralized to corps.

### **Further additions to Survey units**

Drawing strength with 512 Field Survey Company was augmented by the addition of 50 Indian draughtsmen in September, and a further increase in strength occurred with the arrival of 19 Field Survey Company, though its transport and equipment were delayed. Work in the Tura caves to make them ready for the installation of printing machines and depot stores was progressing, and three machines were erected during September. Most of No. 2 Depot's stores had also been installed there by the end of the month.

### **Survey stores problems**

The situation regarding the supply of printing paper and the many and various technical stores required for map production and printing, was a source of much anxiety. Very little was being obtained through the normal Ordnance channels, and D. Survey was not able to obtain authority to effect his own local purchases of items that might have been available. Attempts were being made to obtain essential monthly supplies of these stores from Eastern Group in India, and also direct from the United States through the British Military Mission in Washington, but so far without success. Future map printing programmes were in danger of being held up as a consequence, and urgent representations were made to the War Office for assistance.

For a fuller account of the Survey stores activities *see* Chapter XIV, Section 9.

### **Second British offensive in Western Desert (November, 1941)**

The second British offensive in the Western Desert started on 18th November, 1941, a quick advance of 50 miles into Cyrenaica being made. To cover the big map issues for this operation, over 800,000 maps had been taken forward to Matruh from the Base Depot, a distance of 300 miles, between 19th October

and the end of the month. They were moved in 3-ton lorries by the South African Survey Company, a very creditable performance.

In addition to 514 Field Survey Company, A.D. Survey Eighth Army had under his control for this operation ten detachments from the South African Survey Company. These were attached to the headquarters of divisions and infantry brigades for duty as navigation parties, for the preparation of special maps, and to assist in the distribution of maps to lower formations. This was the forerunner of the map distribution policy which was subsequently adopted, whereby, in order to ensure that the fighting troops really did get their maps, Survey assumed responsibility for distribution down to divisions. Establishment action was being taken to raise the strength of the Field Survey Depot in both personnel and transport so as to regularize this increased responsibility. For this operation, however, it was necessary to borrow personnel from other units as described above. By the end of December units of Eighth Army had reached the coast near Benghazi, though the town itself was not to fall till nearly a month later.

### **Survey work in Syria and Palestine**

Other detachments from the South African Survey Company were placed at the disposal of D.D. Survey Ninth Army for topographical work along the Turkish-Syrian frontier and elsewhere. The German offensive in southern Russia was causing anxiety in view of the possibility of a future German move southwards through Turkey into Syria and Palestine, and this work on the frontier and in connection with 1/25,000 mapping of selected defence areas in Syria and Palestine was given high priority.

The occupation of Syria had opened up a further potential source of mapping as the French Service Géographique had a mapping installation at Beirut and arrangements were made with them for certain revision work to be undertaken on their own 1/200,000 maps of Syria.

### **Improvement in Survey stores situation**

The stores situation improved considerably during December, and was better than it had been for a long time. This was owing to vigorous action on the part of the Survey Directorate at the War Office, who arranged for a scheme of long-term maintenance provision through Washington. To cover the period until regular monthly consignments would be forthcoming, D. Survey Middle East was authorized to order direct on the United States for stores which were essential to meet urgent operational requirements. As a second resource War Office arranged also for monthly supplies from the United Kingdom to bridge the gap period. Paper supplies from India were also more encouraging.

### **Preliminary mapping work for Tunisia and Italy**

The map production and printing programme was always a pointer to probable future happenings, though, of course, full security cover was at all times introduced into the programmes so as not to draw attention to the real objective. The mapping work now taking place included maps of Tunisia and Italy and, with Russia still stubbornly resisting German aggression, there was a steady demand for maps of Russia and the Caucasus as wall maps for general study.

### **Special survey tasks in the Desert**

During the Eighth Army operations a great deal of work was done to assist the troops to locate themselves in almost featureless country. Trig points and minor topographical features which were marked on the maps were labelled with their names and map references. Artificial marks were erected and labelled in areas where no natural features existed. Tracks, marked on the ground by barrels, were surveyed so that they could be shown on future reprints by a special symbol.

### **Japan enters the war. Survey Conference in India**

December, 1941, was one of the critical turning points of the war. The Japanese attack at Pearl Harbour brought the United States into the war. It was followed, on 8th December, by the landing of Japanese troops in Thailand and north-eastern Malaya, at Hong Kong on the 19th, and the Philippines on the 22nd. A state of emergency now arose in Malaya, Burma, India and the whole of the East Indies. Australia was threatened. In view of the possibility that the Middle East might be called upon to assist in map production for operations based on Malaya or India, the Director of Survey flew to India for consultations.

One result of the new situation in the Far East was that the Australian Field Survey Company was withdrawn from Palestine and returned to Australia for duty in the Pacific Area.

### **Eighth Army retreats from Benghazi**

Benghazi was reoccupied by Eighth Army on 24th December, and by 17th January, 1942, Halfaya, the last remaining German pocket still holding out in the back areas, surrendered. Success was, however, to be short-lived. Rommel staged a counter-offensive and retook Agedabia on 23rd January. A map depot had been established in Benghazi on 15th January but, with the German offensive against Agedabia, it was withdrawn to Derna on the 24th and thence back to Tobruk. By the end of January, the enemy had recaptured Benghazi and Eighth Army was retreating to defensive areas further east in Cyrenaica.

Before Rommel's counter-offensive, and in anticipation of a further British advance towards Tripoli, all the resources of 514 Field Survey Company were employed on the production of a 1/250,000 map of the Agheila area from photographs taken by 60 Squadron S.A.A.F. This had to be put into cold storage until a later date, when Eighth Army would be passing through once more on its final victorious advance to Tripoli and Tunis. The topographical sections of 514 Company were increasingly employed on the fixation of astronomical control points in the desert. 770 miles of car and compass traverse were completed by them.

### **Air photography**

The situation at this time regarding air photography for mapping purposes was bad. At the beginning of January, 1942, 60 Squadron S.A.A.F., operating with Eighth Army, had only one serviceable camera, and no aircraft for survey photography were available with Ninth Army during the month. The photographs were required both urgently and in large numbers, and the failure in

supply had a serious effect on the preparation of 1/25,000 and other maps which were required for operations in progress or planned to take place very shortly.

#### **Changes in Survey organization (early 1942)**

A redistribution of command responsibilities early in 1942 affected survey plans for map supply and distribution. As Ninth Army was now fully engaged in cleaning up and occupational duties in Syria, zones of responsibility between it and the Palestine Base and L. of C. areas were laid down, and G.H.Q. took over responsibility for map distribution in Palestine and Trans-Jordan. Middle East also took over command of Tenth Army in Persia and Iraq, and thereby became responsible for supplying to them their maps and survey stores. The Survey Directorate with Tenth Army was headed by Colonel G. F. Heaney as D.D. Survey.

The appointment of Director of Survey, Middle East, was upgraded to Brigadier in January and the establishment of the G.H.Q. Directorate was increased during February, 1942, by the addition of a D.D. Survey, the appointment being filled by Colonel R. E. Fryer. The newly raised No. 13 Field Survey Depot, mainly staffed by Palestinians, completed its move to Eighth Army in March, thereby releasing most of the detachments of No. 2 Field Survey Depot which became available for other tasks. At this time also the South African Survey Company was reorganized. It was divided into two units, No. 45 (Type A), and No. 46 (Type B). The former returned to the Union in April, leaving No. 46 Survey Company for duty with Eighth Army. A Royal Marine Survey Group, which arrived from the United Kingdom, was placed by G.H.Q. at the disposal of D.D. Survey Ninth Army, and carried out field surveys in the Tripoli-Mina area in Syria.

#### **Survey tasks in the Western Desert and in Syria (Spring, 1942)**

In Cyrenaica the topographical sections of 514 and 512 Field Survey Companies did some ground surveys for map revision, much of which was in the patrol areas of the desert between the British and German forces. They were assisted by armoured car patrols, but strong enemy elements made the work difficult and both units suffered minor casualties in wounded and missing. A survey party was also employed on the reconstruction and maintenance of desert beacons which had been erected for survey and identification purposes. Many of these had been tampered with by our own troops and it was necessary to have an Army Order published forbidding unauthorized interference with survey marks and beacons. During these spring months of 1942, the survey units with Ninth Army in Syria were engaged mainly on work connected with the production of 1/50,000 sheets in the Turkish frontier region, and the provision of control for maps of important defence areas in Palestine, and around Damascus, Tripoli and Ras Baalbek. Air photography for mapping continued slowly, depending upon the availability of aircraft and cameras in the Agheila and Agedabia areas of Eighth Army and along the Turkish frontier in Syria.

#### **With Tenth Army in Iraq and Persia. (See Chapter VII.)**

Survey activities with Tenth Army in Iraq and Persia were complicated by political troubles between the Persian Government and the Kurds. It was desired to send survey parties from Iraq into Kurdistan, and this was arranged after some difficult and protracted negotiations. The 2nd and 4th Indian

Field Survey Companies therefore began triangulation work and ground surveys for  $\frac{1}{4}$  inch and 1/100,000 mapping. Further difficulty was encountered owing to the Russian refusal to permit the entry of British survey parties into their zone in north-western Persia to carry through their triangulation programme. A mobile Reproduction Section was sent to Tenth Army overland *via* Baghdad during June to join No. 4 Indian Field Survey Company at Hamadan. This entailed the supply from Middle East of an overland convoy of reproduction stores, thus giving Tenth Army about six months' reserve stocks of these essential stores.

### **Eighth Army retreats into Egypt**

June, 1942, was a black month for Eighth Army. It was forced back from Cyrenaica into Egypt and by the beginning of July, Rommel and his Afrika Korps had thrust deep towards Alexandria, being held up in the El Alamein area. This led to a reorganization of map supply arrangements involving the move back of considerable quantities of maps by the Eighth Army depots, and the destruction of certain stocks which could not be transported. During the retreat, when divisional headquarters were frequently moving, locations given by them were often out of date by the time that the map lorry reached the spot, and deliveries were, for the most part, made only to Corps H.Q.s. A consignment of 1/50,000 maps was sent to Tobruk by ship on the night that the fortress fell.

514 Field Survey Company was very heavily engaged on map printing with its mobile equipment. It had to move five times, but even so, the number of impressions printed for use during the retreat was about 1,000,000. On reaching the Alexandria area towards the end of the month this unit reverted to G.H.Q. control.

Owing to the potentially dangerous situation caused by the German advance into Egypt, it was decided to move a portion of the survey stores and equipment from the Tura Caves to safer places. As a first measure 20 tons of these, including theodolites which were so difficult to obtain at that time, were moved over to the east side of the Canal. Later it was decided to send about 25 per cent of the Tura stocks of paper and survey stores to Palestine and the Basra Base area in Iraq, and another consignment to the Sudan. By the end of July over 100 tons had been removed to Palestine. The building up of bulk map stocks in Palestine was another important item during July. Sections of several field survey companies were used for these map distribution duties, and depots for holding about 1,000,000 maps were opened up. The existing depots at Gaza and Jerusalem were increased in importance and size.

524 Field Survey Company, a new unit made up of Palestinian personnel, was in process of formation, and survey resources in Iraq and Persia were increased during the month by sending 19 Field Survey Company to Ahwaz *via* Baghdad. The headquarters of the mobile echelon and three topographical sections of 512 Company were trained in small scale plane-tableing to fit them for 1/100,000 survey work in Persia.

### **Changes in Higher Command**

August was relatively quiet on the critical front of Eighth Army, and there were no active operations on the fronts of other armies in the Middle East Command. It was, however, a month of momentous changes in the Higher

Command. General (later Field-Marshal) Alexander became Commander in-Chief, and General (later Field-Marshal) Montgomery took over command of Eighth Army. At the end of August it was decided to form a separate command to control operations in Persia and Iraq. This splitting of the Middle East into two commands, though not increasing the geographical survey commitment, undoubtedly added to the work very considerably, as more troops would be moving into the area, and more and better maps would be required of areas for which the existing map coverage was poor.

#### **Ground surveys in the El Alamein area**

Important control and ground surveys were carried out in the El Alamein area during August, including work for R.A. surveys owing to the lack of sufficient R.A. Survey units. Track surveys and desert beaconing continued to be an important item of field work done by 514 Company, extending eastwards from the El Alamein area, and southwards for about 50 miles.

#### **Organizational changes in G.H.Q. Survey Directorate (Autumn, 1942)**

An organizational change affecting the G.H.Q. Directorate was the formation of a new unit known as 525 (G.H.Q.) Field Survey Company. Up till then the Survey Directorate had consisted only partly of personnel engaged on purely survey staff work. Many were employed on technical productive work, including, for example, computing, drawing and map production for local needs, all of which were essential at G.H.Q. The necessity for technical survey personnel at Headquarters was not always readily apparent to Establishment Committees who were naturally concerned with keeping down the size of staff branches at all headquarters, and who, somewhat naturally, insisted frequently that the survey staff was top-heavy, assuming that all the personnel were engaged on staff work proper. The transfer of the production personnel to the new G.H.Q. Company helped to remove this difficulty. The unit was largely formed out of the personnel of the Survey Directorate, which was thereby considerably reduced in numbers. Its functions included computing, map distribution and production and, by the nature and purpose of its work, it was necessary for it to work in conjunction with the Survey Directorate. In September three U.S. survey officers arrived in Cairo and were located alongside the G.H.Q. Directorate. This was the first official contact between the British and U.S. Survey organizations in the Middle East.

#### **Unsatisfactory situation regarding air photography (Autumn, 1942)**

The situation regarding air photography for mapping purposes continued to be unsatisfactory, very little photography being possible owing to lack of aircraft. A programme was planned to cover the large area of the Qattara Depression-Faiyum-Bahariya Oasis, but little progress was made. In view of the operations which were shortly to take place this fact was of particular significance, and points once again to the essential need to provide an adequate number of the right type of aircraft in time to ensure the provision of survey photographs for the mapping of vital areas.

#### **Block-plots**

It was during this preparatory period leading up to the battle of El Alamein that the "block-plot" was introduced. The enemy was building up enormous

strength in defences and gun positions, and it was important that our artillery should hammer these and endeavour to knock them out before our forces were committed to the assault. To effect this, it was vital that the co-ordinate positions of the enemy guns and defences should be determined with reference to the surveyed positions of our own guns, so that the guns could be laid accurately on to their targets. The Artillery counter-battery officers were asking for these co-ordinates with urgency. The block-plot was compiled by drawing the map grid on a large scale, and on this grid were plotted the principal points (or centres) of the photographs which covered the area in the form of strips of overlapping photographs. Having located on newly taken reconnaissance photographs the positions of the enemy guns and defence works, their positions with reference to the map grid were determined on the block-plot by a process of graphical intersections from the principal points of the photographs already plotted on the grid. The use of these block-plots met with very great success, and was undoubtedly a great aid to the effective artillery preparation for the battle itself. Between 27th October and 2nd November, 215 new enemy gun positions were located, and a very large proportion of these were destroyed. Map sheets on 1/25,000 scale were also prepared to cover selected areas of the battle-front, on which the enemy defences were overprinted from large scale air photos. All this work was done from whatever photographs could be obtained at the time. It could have been done very much quicker and with much greater accuracy if proper survey photos had been available.

#### **Opening of British offensive at El Alamein**

On the night of 23rd/24th October, 1942, the British offensive at El Alamein was launched. Shortly before that date Colonel V. E. H. Sanceau assumed duty as D.D. Survey with Eighth Army, and remained with it right through to the later stages of the campaign in Italy. His Survey Directorate was augmented so as to include one A.D. Survey, one D.A.D. Survey, and Survey Liaison officers (Captains) at the rate of one for each corps under the Army command. Map distribution for the battle was extensive, no fewer than 630,000 maps having been issued from the army map depots during October. For the battle itself, a fifth edition of the 1/50,000 map of the battle area was published showing enemy defences plotted from last-minute air photos. The Survey units operating with Eighth Army were 46 (South African) Survey Company and 517 Field Survey Company R.E. The field section personnel were trained in resection methods by night from fixed vertical searchlights, the idea being to determine the position of units moving forward during the battle in desert country where there were very few landmarks to aid the normal methods of identification of position. Survey parties accompanied the leading infantry brigades on the opening night attack, but the method outlined above did not meet with much success as the searchlights were far back, and the formations to whom the survey parties were attached did not seem to know how best to make use of these skilled surveyors. The clouds of dust and sand which arose as the result of gun-blasts and shell explosions soon enveloped the whole battle area in such a thick fog that it is doubtful whether the vertical beams could have been seen even if the searchlights had been placed very much further forward. As the battle developed, the sections of 46 Survey Company were employed on beaconing areas behind the forward positions, fixing start lines, and marking lines of advance.

### **The advance through Libya**

The rapid advance of Eighth Army in November introduced many difficulties in map distribution. 13 Field Survey Map Depot, which was serving Eighth Army, moved its main depot by rail from Ikingi to Matruh on 21st November, and then on by road to Tobruk on the 29th. A railhead depot had previously been formed, which moved forward with railhead, and further west still was the forward map dump, functioning as an advanced depot detachment and feeding the formation map lorries which accompanied the headquarters of corps and divisions.

During December the battle moved so far westwards that the forward survey troops of 46 (South African) Survey Company were, by the end of the month, over 1,000 miles away from base. With such long lines of communication, bulk stocks of maps and survey stores were sent by sea to Benghazi. Air and road transport was also used. 13 Field Survey Depot moved forward from Tobruk to Benghazi.

As soon as the success of the operation had been assured, thoughts were directed to the future link-up between Eighth Army and the allied forces fighting their way eastwards into Tunisia in North West Africa. An exchange of signals and map material between the respective survey organizations was effected during December, and this contact continued and expanded during the subsequent months, involving much co-ordination of map production work in preparation for the final operations for driving the enemy out of Africa.

The formation of new Palestinian units continued during December. 14 Field Survey Depot completed formation and was sent to join Paiforce, and two more depots were being raised. The formation of 524 Field Survey Company with Palestinian personnel was nearing completion, and part of it was employed on productive work under A.D. Survey B.T.E.

The lack of good maps covering the battle area at Agheila necessitated the hasty production of new maps in the field. This was done by plotting from air photos, using newly fixed ground control, all this work being done by 46 (South African) Survey Company. Much difficulty was experienced owing to the minefields which were encountered on most of the vantage points selected for surveying the ground control, and there were several casualties. Enemy opposition, bad weather, and shortage of aircraft hampered the production of survey photographs required for the work.

Amongst other tasks, 517 Field Survey Company undertook the survey of the wrecked ships in Tobruk harbour, in conjunction with the Fleet Hydrographic officer. This unit also did a re-survey of part of the Egypt-Libya frontier, where the existing 1/50,000 maps were little better than rough sketch maps.

### **Survey organization in the Middle East at the end of 1942**

The Survey organization in the Middle East at the end of December, 1942, was as follows:—

*G.H.Q.* (D. Survey—Brigadier R. Ll. Brown).

Survey Directorate.

525 (G.H.Q.) Field Survey Company R.E.

512 Field Survey Company R.E. (less detachments).

524 Field Survey Company R.E. (less detachments).

2 Field Survey (Map) Depot R.E. (less detachments).  
11 Field Survey (Stores) Depot R.E. (less detachments).  
Base Survey Drawing and Photo Process Office.

*Eighth Army*

Survey Directorate.  
46 (South African) Survey Company S.A.E.C.  
517 (Corps) Field Survey Company R.E.  
13 Field Survey (Map) Depot R.E.

*B.T.E.*

Survey Directorate.  
Detachment of 512 Field Survey Company R.E.  
Detachment of 524 Field Survey Company (Palestinian).

*Palestine Base and L. of C. Area*

Survey Directorate.  
Detachments of 2 Field Survey (Map) Depot R.E.  
Detachments of 512 Field Survey Company R.E.  
Detachments of 11 Field Survey (Stores) Depot R.E.  
514 Field Survey Company R.E. (less detachments).  
15 and 16 (Palestinian) Field Survey Map Depots.

*Ninth Army*

Survey Directorate.  
13 (Corps) Field Survey Company R.E.  
Detachments of 514 Field Survey Company R.E.  
Detachments of 512 Field Survey Company R.E.  
Royal Marine Survey Group.  
9 Field Survey (Map) Depot R.E.  
Service Géographique (French) at Beirut.

*Paiforce*

Survey Directorate.  
19 Field Survey Company R.E.  
14 Field Survey Map Depot (Palestinian).  
10 Indian Field Survey H.Q.  
1 Indian Field Survey Company I.E.  
12 Indian Drawing Section.  
14 Indian Computation Section.  
88 Indian Survey Park Section.

*Tenth Army*

Survey Directorate.  
2 Indian Field Survey Company I.E.  
4 Indian Field Survey Company I.E.  
13 Indian Drawing Section.

### Survey activities in Tripolitania

The capture of Tripoli towards the end of January, 1943, considerably eased the difficulties of supplying maps and survey stores to Eighth Army, as consignments could be despatched there by sea. The Advanced Map Depot moved to a site just outside Tripoli at the end of January, where it was shortly joined by the Main Depot which now changed its title from No. 13 to No. 20.

Until the fall of Tripoli it was expected that the enemy would stand and fight at Buerat, and considerable survey preparations were made for such a

battle. 1/50,000 maps were published with enemy defences overprinted, and 46 (South African) Survey Company established ground control for the artillery and for air-photo programmes in the Buerat and surrounding areas. Much of this work was wasted effort as the air photographs did not materialize. 60 Squadron S.A.A.F., whose aircraft had nearly reached the end of their operational life, made two gallant efforts to obtain photographs of the strong enemy positions further to the west at Mareth, but one of these resulted in a crash on the homeward journey involving the death of the pilot, and the squadron was grounded while awaiting further aircraft. Towards the end of February two Mosquito aircraft were allocated to the Squadron for survey photography, and the installation of survey cameras was put in hand. As these were the only two Mosquitoes in Middle East it was a welcome indication that the importance of survey photography was at last being recognized.

### **Mapping and survey for operations in Tunisia**

The G.H.Q. Computation Section was now engaged on an extensive programme of work for the preparation of trig lists of Tunisia, including many points which were urgently wanted by Eighth Army for the Mareth area, which was reached early in March. During February the survey units had concentrated most of their efforts on the production of new 1/50,000 maps in the Gabes, Mareth, and Medenine areas as this part of Tunisia had been only spasmodically mapped by the French. To assist in this field-mapping programme, No. 7 General Survey Section R.E. was formed by G.H.Q. and sent to Eighth Army.

The alteration in the general strategical situation in North Africa produced many changes in the programmes of work that were in hand with G.H.Q. Survey units at Cairo. The Tunisian programmes for new and revised maps on all scales were completed, and kodak film negatives for 1/100,000 and 1/50,000 maps and for town plans were supplied to Eighth Army so that they could be printed in the field on their mobile equipment. New mapping programmes were now taken up for Sardinia, Corsica and Italy, based on War Office material which was sent out to the Middle East. The mapping of Greece, Crete and the Dodecanese and Aegean Islands was based on War Office material or captured maps, with revision from air photographs and other information obtained locally. Trig list preparation for these areas was also undertaken.

With the advance of Eighth Army into Tunisia, survey duties in Cyrenaica, including map distribution, were taken over by the Survey Directorate B.T.E. In the Trans-Jordan Desert the survey units of Ninth Army continued to do much useful work with Paiforce. Paiforce had lost at this time No. 2 Indian Field Survey Company which returned to India, and approval was given for the formation of a Polish Artillery Survey Regiment, a Polish (Corps) Field Survey Company, and a Map Depot.

March and April, 1943, were busy months of intensive survey preparation for all possible future operations in which the Middle East might be involved. A quantity of new mapping, much of it from air photographs, was done and, to provide an increase of drawing power, 13 Field Survey Company, 514 Field Survey Company and the drawing sections of 19 Field Survey Company were concentrated at the old survey camp at Abbassia, 19 Company having returned to Middle East Command from Paiforce during April.

During May the final operations in Tunisia cleared all enemy forces from

Africa and the stage was therefore set for the next phase. With the accomplished junction between Eighth Army and the allied forces operating from North West Africa, changes took place in the higher direction of survey activities. Brigadier Brown was transferred to become Director of Survey at Allied Force Headquarters (A.F.H.Q.) in Algiers, and he was succeeded at G.H.Q. Middle East by Brigadier R. E. Fryer.

#### **A.F.H.Q. takes over control**

Operational control in the Mediterranean now switched across to A.F.H.Q., and the Middle East survey organization became an extremely active and important map production agency for all operations based in the Mediterranean and surrounding areas. June was probably one of the busiest months that Middle East Survey had as yet experienced. As "D"-day for the operations in Sicily approached, the main activities tended to shift from map production to distribution. Coding and bundling under the strictest security conditions was an arduous task for all those concerned.

Two changes occurred in the air-photo supply organization during June; firstly, 1434 Flight R.A.F. which, with its Maryland and Baltimore aircraft, had done such useful work in Syria and Persia, was now disbanded as, owing to lack of suitable aircraft, it was unable to undertake tasks outside non-operational areas; secondly with the shift of operational activity to the west, 60 Squadron S.A.A.F. was placed under the operational control of A.F.H.Q.

There were changes also in the map distribution organization. No. 20 Field Survey Depot was reorganized on a new war establishment as 20 (Army) Field Survey Depot including extra transport and further British and Palestinian personnel. The newly raised No. 18 (Palestinian) Field Survey Depot operating with Paiforce took over the map depots at Baghdad and Kirkuk, and a detachment of No. 14 (Palestinian) Field Survey Depot took over the depot at Tehran.

11 (Polish) Field Survey Company and the Polish Map Depot were now in commission and undergoing training. Pending the arrival of demy size printing equipment from the United Kingdom they were supplied with one double-demy printing trailer and ancillary equipment so that they could start productive work.

#### **The invasion of Sicily ("Husky")**

Operation "Husky" was launched on 10th July, 1943. A full account of the survey action connected therewith is given in Chapter XII, Section 4, but it is well to record here the part taken by the Middle East Survey Directorate and units in planning and preparation. The invading force consisted of the British Eighth Army and the U.S. Seventh Army forming together 15 Army Group, under the higher command and control of General Eisenhower at A.F.H.Q.

Towards the end of February, 1943, while First and Eighth Armies were still heavily committed in Tunisia, G.H.Q. Middle East held an exercise designed to study the probable requirements for an assault on the Sicilian coast. A planning staff (Force 545) was then assembled in Cairo to carry out planning for British participation in the operation. Long-term mapping preparations had for some time been in progress in London and Washington, and the War Office was asked for full details of the mapping programmes for Sicily and Italy and the islands in the vicinity. This information was made available during the first week in March.

The Director of Survey, Middle East was kept fully in the picture by the Cairo planners, but it was clearly necessary that a survey planning officer should be appointed to work with the rest of the planning staff to study and make arrangements for all the mapping and survey requirements.

At that early date it was not known which headquarters would eventually conduct the British element of the assault and, in any case, D.D. Survey, Eighth Army was in Tunisia where First and Eighth Armies were fighting the closing battles to clear the enemy out of North Africa. Those operations did not, in fact, end till 12th May, and as the target date for "Husky" was originally a date in June, later postponed till 10th July, it is a matter for conjecture whether D.D. Survey, Eighth Army could or should have been spared from his Army H.Q. in Tunisia in order to conduct the early survey planning in Cairo which started in March.

In the event D. Survey, Middle East appointed one of his own officers to act as D.D. Survey (Planning) for "Husky" and the survey preparations went vigorously ahead. It was not until the end of April, by which time it had been settled that Eighth Army would take part in the assault, that Colonel Sanceau (D.D. Survey, Eighth Army) was sent across from Tunisia to Cairo to take over responsibility for survey planning.

There were many difficulties in co-ordinating the work of various map production authorities which were as far apart as London, Washington, Algiers and Cairo, but the final result, with regard to map supply and distribution for the British force, must have given much satisfaction to all those who shared the immense labour of preparation.

The survey units available in Cairo for map preparation were 13, 512, 514, and 524 Field Survey Companies R.E. The first of these was scheduled to take part in the operation, and it was known that it would be withdrawn for training and other duties some time during the planning stage.

The following survey units, hitherto belonging to Middle East Command, accompanied Eighth Army to Sicily:—

- Survey Directorate, Eighth Army.
- 13 and 517 Field Survey Companies R.E.
- 7 General Field Survey Section R.E.
- 20 (Army) Field Survey Map Depot R.E.

#### **Summary of survey activities in the Middle East (July, 1943 to August, 1945)**

Once the successful assault into Sicily had been accomplished the interests and activities of the Survey Directorate, Middle East, then shifted, to a large extent, to possible future developments, which were not easy to predict. With this end in view some preparatory regrouping of survey resources and personnel was undertaken.

In order to provide a central organization to direct and check air photographic work on large revision projects, a small Air Survey Group was formed as part of the Survey Directorate at G.H.Q. The ever-increasing amount of work connected with map stocks had made it necessary to attach technical survey tradesmen to do map depot duties, which was obviously a wasteful use of skilled personnel. During August, therefore, the war establishment of 2 Field Survey (Map) Depot was amended, and the unit was then composed almost entirely of Palestinian and Jewish personnel. The Tripoli Base now became

Tripoli District, and the responsibilities of 20 Field Survey (Map) Depot, when it moved over to Sicily, were taken over by 16 (Palestinian) Map Depot.

Paiforce had many changes of units during July, the following leaving the Command:—

- 1 Indian Field Survey Company I.E.
- 4 Indian Field Survey Company I.E.
- 10 Indian Field Survey H.Q.
- 21 Survey Park Section I.E.
- 51 and 52 Drawing Sections.
- 14 Computation Section.

Since their arrival in the Command in 1941, the above units had done great work. Over 200,000 square miles in Iraq and Persia had been resurveyed or revised at scales of 1/100,000 or  $\frac{1}{4}$  inch, and about 4,500 square miles of new mapping from air photographs at 1/25,000 and 1/50,000 scale had been accomplished. Over 2,500 miles of triangulation had been completed for plane table control. The country in which they had worked varied from the plains of Iraq to the mountains of Persia, where the surveyors had often to operate at altitudes exceeding 10,000 feet, and in temperatures varying from 0° to 127° Fahrenheit.

To take the place of the departing units the following were formed in Paiforce mainly by drawing men from Nos. 1 and 4 Indian Field Survey Companies:—

- 81 General Section I.E.
- 82 Ground Survey Section I.E.
- 83 Reproduction Group I.E.

Early in September the Polish Survey units left Paiforce on transfer to Ninth Army in Palestine.

After the above moves the Survey organization in Paiforce consisted of:—

- Survey Directorate (Lieutenant-Colonel L. de V. Carey, R.E.).
- 81 General Section I.E.
- 82 Ground Survey Section I.E.
- 83 Reproduction Group I.E.
- 14 (Palestinian) Field Survey Map Depot R.E.
- 18 (Palestinian) Field Survey Map Depot R.E.

With the departure of Eighth Army from Middle East Command, 46 (South African) Survey Company was mobilized as a general service unit to be available for service anywhere. The outstanding performances of this unit since its arrival from East Africa, and its exploits from El Alamein to Tunis, were deserving of the highest praise. The unit later moved to Tripoli (Libya) by road on 6th September *en route* for service elsewhere.

The autumn months of 1943 were, for Middle East Survey, relatively quiet operationally. The map production, revision, and computing personnel were, however, engaged at high pressure on work mainly for A.F.H.Q. operations in Italy, and also in preparation for other possible emergencies in the Balkans, south-eastern Europe, or Turkey. The Survey Directorate was also responsible for the preparation and equipment of survey units which were sent to join the allied forces in the Central Mediterranean. Survey representation at H.Q.

B.T.E. was withdrawn during January, 1944, and G.H.Q. took over all survey duties for British troops who remained in Egypt.

Relatively static conditions continued throughout the whole of 1944, but heavy fighting continued in Italy. In western Europe operation "Overlord" was gradually but surely destroying the German Armies in France and Belgium. Middle East Survey turned out record quantities of maps on an agency basis for A.F.H.Q., and opportunity was taken to improve the triangulation connections in Tripolitania and along the boundaries between Syria, Palestine and Trans-Jordan. Observations were also carried out to effect a junction between Syria and Cyprus.

There were a certain number of unit movements during the year. Mention should be made of the Basuto personnel who were employed with 19 Field Survey Company, and who added to their battle honours by going to Italy when that unit was transferred to the Central Mediterranean Force. 49 (South African) Survey Company, which came up from South Africa, also went to Italy. In June, 14 Field Survey (Map) Depot was transferred to Italy and 15 (Palestinian) Field Survey Depot assumed duty at G.H.Q., thus releasing British personnel for other duties. Later, in September, 524 (Palestinian) Field Survey Company was also sent to Italy.

There was a change in the Survey command during April, 1944. Brigadier R. E. Fryer was posted to the United Kingdom and was succeeded, as Director of Survey, Middle East, by Brigadier K. M. Papworth on transfer from Paiforce.

The scheme for repatriation of personnel who had completed long periods of service abroad involved numerous changes during 1944. The successful prosecution of the war in western Europe, with its inevitable effect of diminishing the probability of further serious operations in the Middle East, brought about a consideration of establishment reductions affecting both survey staffs and units. During February, 1945 the Persia-Iraq Command ceased to function separately, and was amalgamated once more with Middle East Command.

The German surrender in Italy and the rest of western Europe put an end to the urgency of operational mapping programmes for A.F.H.Q. Unfortunately, the cease-fire in Europe was celebrated in Palestine and Syria by political disturbances involving the intervention of British troops and the inevitable rush requirements for maps. At the end of June, 1945, the Survey Directorate Ninth Army was closed down and Colonel R. P. Wheeler succeeded Colonel E. B. Elkington as D.D. Survey, Military Forces in Palestine, taking over also the responsibility for the survey requirements of Ninth Army.

In August, 1945, Brigadier Fryer once more assumed duty as Director of Survey, Middle East, relieving Brigadier Papworth who returned to the United Kingdom. Although active operations against the Axis Powers were over, the survey activities of G.H.Q. continued at high pressure, and embraced wide areas of responsibility. The state of unrest which continued to prevail over a large part of the area constituting the Middle East Command was greatly felt by the Survey Directorate. Maps of areas which had been considered operationally inactive were suddenly demanded in large numbers. After the cessation of hostilities with Japan, there was a natural feeling of relief, and an inclination to ease the strain of continuous high pressure, but this had to be repressed, as the survey responsibilities under the conditions of troubled peace which persisted were almost as vital as during active hostilities. The situation was complicated

and rendered more difficult by the operation of the repatriation and demobilization schemes.

Big programmes of post-war air-survey photography over selected areas in Persia, Iraq, Syria and the Levant were put in hand, involving much work for field surveyors in the production of the necessary control.

This historical summary may well close at this stage. The more technical aspects of the work undertaken are dealt with in other sections of this chapter. It will be clear, however, that, under the control of successive Directors of Survey, the organization set up by Brigadier R. L. Brown and his staff early in 1940 played an important and not inconsiderable part in the successful operations in East and North Africa, in Persia, Iraq, and Syria, in Sicily and Italy, from the first offensive in December, 1940, against the Italians in Libya, until the final German surrender in May, 1945.

## SECTION 2. MAPS AND MAP PRODUCTION

### Pre-war mapping arrangements

In 1937 the War Office considered the problem of providing maps for British troops in Egypt in anticipation of a possible war emergency. At that time there was no possibility of sending out a survey unit to do any survey or mapping work in Egypt as no such units were in existence. There was, however, a Survey Department with headquarters in Cairo which was an Egyptian Government organization. It was a purely civil department with no military connection. The Surveyor General was an Egyptian, the remaining senior officials in charge of the various sub-departments being British.

An officer was therefore sent out to Egypt from the Geographical Section General Staff (M.I. 4) during 1937 to examine the situation with special reference to map coverage for the Western Desert, and to consider the question of air photography for mapping purposes over the same area.

As a result of this visit the following decisions were taken and implemented:—

- (a) Mobilization stocks of maps for the Western Desert area were printed in Egypt and stored there.
- (b) Air photography by the R.A.F. was begun in the coastal zone with a view to extending the surveyed area southward to the Qattara Depression.
- (c) Black impressions of these mobilization maps were obtained from Egypt. One set was held by the War Office and one set by the Survey Department of India, so that production could be undertaken in either place if the Survey Department in Egypt were put out of action before military map printing resources were available there.
- (d) Black impressions of certain War Office map series were sent to the Survey Departments in India and Egypt so that they could undertake reproduction and printing of such maps if so required.

Air photography proceeded very slowly and was stopped altogether in 1939, as by that time the Survey Department of Egypt had produced by normal ground methods all the maps which it was then considered would be required by the British troops. Amongst their other tasks the R.A.F. photographed a small area round Mersa Matruh.

With regard to Palestine, maps of that country for training and other

purposes were customarily provided on an agency basis by the Palestine Survey Department. The agreement was that as soon as the maps had been provided the War Office held themselves responsible for replacing the paper used. As there was always a considerable delay in effecting this replacement a dangerous situation frequently arose when the Survey Department was almost completely devoid of paper stocks. This happened during the crisis period in 1938 and though at that time it was not considered likely that Palestine would become a theatre of operations, the following action was taken:—

- (a) The War Office arranged for a reserve stock of paper to be held by the Palestine Survey Department.
- (b) Plates of the Palestine 1/100,000, 1/250,000 and 1/500,000 maps were obtained and held by the War Office.
- (c) Black impressions of the 1/100,000 series were sent to the Survey of India for reproduction action if so required.

#### **Mapping situation on mobilization**

As one of its principal tasks during peace-time M.I. 4 (Geographical Section, General Staff) was responsible for keeping a record of all known maps produced in foreign countries, and for obtaining record copies of them where possible for the War Office Map Library. For those areas over which it was considered that British troops would most probably operate in the event of war, it was the responsibility of M.I. 4, on receipt of instructions from the General Staff, to reproduce the appropriate maps either by facsimile copying from the national maps or by new drawing and compilation, to bring the maps up to date by revision from any material that could be obtained, and to ensure that printed stocks would be available on mobilization. The area of operational interest in the Middle East was a very extensive one, including Egypt and the Sudan, Libya, Palestine and Trans-Jordan, Syria, Iraq, Turkey, Persia, Greece, the Dodecanese Islands and the Balkans generally. In addition there were the British and Italian East African possessions including Abyssinia.

In view of Germany's aggressive attitude, involving extensive mapping programmes for a probable European war, it was clearly impossible at the same time to reproduce and print operational stocks for vast areas of south-eastern Europe and western Asia which were only possible and not probable war theatres.

For the Middle East, therefore, the War Office arranged, as indicated above, for mobilization stocks of maps covering Egypt and the Western Desert to be printed by the Survey of Egypt, and held at British Military Headquarters in Cairo. There were a number of War Office (G.S.G.S.) editions of maps covering large areas of south-eastern Europe, western Asia and Africa of which small stocks were available in the United Kingdom, and for which reproduction material could be prepared quickly.

It should be realized that, under peace conditions, the War Office normally has no means of carrying out its own surveys over foreign territory in order to produce maps for possible operational purposes. It is entirely dependent, during peace, on making use of the national maps which the Survey Departments of foreign countries produce for their own use, and on obtaining any other information or material which will serve to bring those maps up to date, especially with regard to road and rail communications and other essential features of military importance. Having collected copies of all such maps the

Geographical Section, or its military Survey organizations overseas, can reproduce those required either by recompilation and new drawing, or by direct copying and reproduction by photo-lithographic processes. Whatever methods are used, but more especially when new drawing and extensive revision is entailed, the preparation of an extensive map series is a slow and laborious undertaking, and requires very early consideration by the General Staff when planning for possible future operations.

During the winter of 1939-40 Colonel R. Ll. Brown, who at that time was serving with the B.E.F. in France, was appointed Director of Survey for the Middle East. He returned to the United Kingdom to be briefed for his task and to collect his Survey Directorate staff. While waiting to go to Egypt he visited Paris to consult with the French Service Géographique on various subjects concerning cartography and triangulation for those areas in the Middle East in which the French had a special interest, and for which they possessed technical survey and mapping material.

In the survey dossier handed to Colonel Brown he was given details of the existing mapping situation covering the Middle East theatre, embracing parts of Europe, Asia and Africa. The cartographic information which this placed at his disposal included the following:—

- (a) A brief summary of all the known map series on various scales which existed for the various countries. This summary gave the scale, approximate date of each series, the area covered, the number of sheets, whether coloured or in black only, details of the map projection used, and remarks on the contouring or other method of showing hill features and heights.
- (b) A list of mapping material which was being handed over to him.
- (c) A list of special maps and town plans which had been ordered by Headquarters, Middle East and which were in production at the War Office.
- (d) Notes on the G.S.G.S. map series which were available for the area in question.
- (e) Information regarding the stock of printed maps which were being supplied to the Survey Directorate in the following two categories:—
  - (i) From home sources. This category consisted of limited stocks of G.S.G.S. map series of the area as well as small stocks of outline maps for staff use. This stock from home sources was intended for strategical and staff purposes only, and there were not sufficient quantities available either for a fighting or training issue.
  - (ii) Already held in Egypt. These, as referred to previously, were the stocks printed by the Survey of Egypt and held out there, so as to allow British forces to undertake operations without delay if the emergency should arise.
- (f) List of G.S.G.S. maps for which black impressions were held by the Survey Departments of Egypt and India. From this list D. Survey would be in a position to order reproduction of any particular map for which he considered there was urgent need.

The strategic requirements in small scale maps for the planning and operational staffs were met by the G.S.G.S. series on the 1/M and 1/2M scales. With the entry of Italy into the war it was obvious that the priority areas for tactical maps were those covering the Western Desert and Libya, and those adjacent to and including the Italian East African colonies and Abyssinia.

Egypt and the Western Desert were covered by an Egyptian series at 1/100,000 scale. This was made up of the following:—

- (a) Normal series covering an area from El Daba in the west to the east side of the Suez Canal, and the whole of the Nile Valley to Wadi Halfa.
- (b) North Coast series extending from the western limit of the normal series to the Libyan frontier.
- (c) Western Desert series extending the North Coast series southwards.
- (d) Northern and Southern Sinai series, covering the whole peninsula except for a small central area.
- (e) Eastern Desert series. This covered a small part only of the area between the Nile and the Red Sea.

On the 1/25,000 scale the Survey of Egypt had concentrated mainly on the cultivated areas. The following were covered by maps on this scale:—

- (a) The whole of the Delta extending from Alexandria up to and including the Canal.
- (b) The Nile southwards to Beni Suef.
- (c) A stretch of the Nile from Asyut southwards.
- (d) Another stretch from Aswan northwards.
- (e) Matruh area.
- (f) Daba area.

The Egyptian Survey Department had also published a four-sheet series covering Egypt on a scale of 1/500,000.

Subsequent to these mapping and stock arrangements which had been made by the War Office, the initiative for further mapping programmes and production in the Middle East lay with the Director of Survey, Middle East.

### Map printing resources

To enable D. Survey to be more or less independent with regard to map production and printing, 512 (Army) Field Survey Company R.E. was sent out to Cairo early in 1940. From the map printing aspect this was a static unit equipped with fast running double-demy litho printing machines, cameras, and ancillary plant. It also had a number of small drawing sections, and these were increased in numbers very shortly after arrival, when D. Survey recognized that the programme for new mapping and revision was going to be a very heavy one. Throughout the entire war in the Middle East this unit played a predominant part in the immense task of map production which was undertaken, not only for those operations which came under the direct or indirect control of G.H.Q. Middle East, but later, on an agency basis, for the operations in Sicily and Italy which were under A.F.H.Q. control.

Further map printing resources were provided by the mobile printing sections of the field survey companies which, arriving at intervals in the Middle East, were employed in various parts of the theatre, and accompanied the armies in the field during operations. In addition there were the civil survey departments in Egypt and Palestine and, at a later stage, the French Service Géographique at Beirut. In Greece also there was a national Survey Department which gave a great deal of assistance during a critical time.

### Early operational mapping activities

On arrival in Cairo during February, 1940, D. Survey took over the mobilization map stocks which had been assembled there, and obtained all available information from the planning and operational staffs at G.H.Q. of future intentions and probabilities.

The grid systems adopted for the various zones within the theatre are referred to briefly below (see Diagram 2 on page 112):—

- (a) *Egypt.* H.Q. B.T.E., in conjunction with the local Survey Department, had established two Transverse Mercator grid belts for Egypt. One of these, known as the Red Grid, extended from longitude 29° (E.) to the eastern frontier. The other, known as the Purple Grid, extended from longitude 29° (E.) to the Libyan frontier. These were accepted by the War Office.  
H.Q. B.T.E. had also introduced its own system of map referencing, which was at variance with the accepted British system of letters and numbers.
- (b) *Palestine.* A Transverse Mercator grid covered Palestine and Trans-Jordan. This extended from the eastern limit of the Egyptian Red belt to its junction with the Iraq grid in the east, and northward to its junction with the Levant grid just north of Haifa.
- (c) *Levant.* The Levant Grid covered Syria and the Lebanon and a small area of Turkey in Asia. It was bounded by the Palestinian belt in the south, the Iraq and Caucasus zones in the east, and the Mediterranean zone in the north and north-west.
- (d) *Cyprus* was covered by its own grid.
- (e) *Turkey in Asia* was covered by the Mediterranean Grid Zone which extended eastward to its junction with the Caucasus Zone.
- (f) *Libya.* It was decided to cover Libya by a Lambert Grid which extended westwards from its junction with the Egyptian Purple Grid. Its western and southern limits had not been defined in 1941, but a junction with the N.W. African Grid was later effected. With the almost certain probability that operations would be conducted over long distances east and west, and limited distances north and south, the Lambert projection was very suitable technically for military purposes.
- (g) *Crete.* This island was covered by its own grid.
- (h) *Greece* was covered by the western end of the Mediterranean Zone Grid which included also both European and Asiatic Turkey.

The political situation regarding Turkey in 1940 was obscure but, with the possibility of establishing air bases in that country and of having perhaps to operate through Turkey to meet a potential threat from the north, it was essential to provide mapping cover. Sheets of the 1/200,000 Turkish maps of western Asia Minor were therefore taken up for reproduction in colour and were gridded (Plate 6), and a few 1/50,000 sheets were produced by enlargement from smaller scales. "Tank Going" maps were also prepared by adaptation of 1/250,000 sheets, and several town plans and other special maps were produced. The reproduction of the Turkish 1/800,000 series was later undertaken and completed during the summer of 1941 together with other maps to which later reference will be made.

With the 1/M International series as basic material, 40 sheets were adapted for special use as aviation maps covering the Balkans and the Middle East.

After the preparation of grid overprints, and the use of printing plates of the standard Egyptian sheets supplied by the Survey of Egypt, stocks of gridded 1/100,000 maps were printed, extending over the Western Desert as far as the Libyan boundary. The War Office mapping preparations for Cyrenaica and Tripolitania consisted of reproductions of a certain number of Italian sheets on medium and small scales belonging to the following series. Only a limited number of sheets in the series was available, several being missing.

(a) *Cyrenaica*

1/100,000. A narrow coastal strip extending from Benghazi to the Egyptian frontier.

1/400,000. Coastal block.

1/50,000. Coastal strip from Benghazi to Derna.

(b) *Tripolitania*

1/400,000. Coastal block.

1/100,000. Coastal strip from the French frontier to Misurata.

1/25,000. Town of Tripoli and surroundings.

(c) *Libya*

1/400,000. Central area extending from the coast well inland.

The Survey Directorate undertook the reproduction, including gridding, of the available sheets from reproduction material supplied by the War Office, and stocks were assembled for the concentration of the Western Desert Force and for the opening of the first British offensive. During the short period before the offensive, the mapping situation around the railhead area of Mersa Matruh was improved by the production of several sheets on 1/25,000 scale, the work being done from air photographs and ground check by sections of 512 Field Survey Company.

There were some points of technical interest concerning the above maps, one of which especially should be recorded, as it gave a good deal of trouble, and added to the difficulties of production. Owing to a break between the triangulations of Egypt and Cyrenaica, the topography of the Egyptian and Italian Surveys did not join up properly. This break resulted in a discrepancy in longitude which was sufficient to affect artillery shooting quite considerably. Its effect on the topographical sheets was also noticeable and, when reproducing the frontier sheets of the Italian 1/100,000 maps in the Sollum area, the War Office had adjusted the Italian detail to fit corresponding detail on the Egyptian sheets without inserting any note on the map to indicate that this had been done. The sheets concerned were therefore reproduced afresh in Cairo from original Italian material, due allowance being made in the gridding for the discrepancy in longitude between the two countries.

The British offensive opened in December, 1940, and rapid advances were made. One of the principal objectives of survey parties operating with the Desert Force was to obtain copies of captured Italian maps, and they were fortunate in this respect. Some of the hitherto missing 1/100,000 sheets were found, and some more up-to-date editions of available sheets were also captured. As there was no survey unit with mobile printing equipment then in the field, the maps were sent back to Cairo where they were rapidly reproduced in one colour and flown up to the front. Later the entire 1/100,000 series, with reorganized sheet lines across the frontier, was redrawn for reproduction in colour.

It was also found that there was a considerable amount of fairly recent Italian 1/50,000 mapping in Cyrenaica, and of special importance was a 1/50,000 sheet of Tobruk, which town was at that time just about to be attacked. This map was reproduced with the British grid, and was flown forward in time for the actual assault. Of particular interest and value was the fact that enemy defence works and gun positions were incorporated in the form of an overprint, thus enabling the artillery to concentrate successfully on these features. At a later stage, some 1/25,000 maps of Tobruk were captured, and it was noticed that these had been produced by the Italians by enlargement from the 1/50,000 map, not from the original Italian material, but from the British reproduction of the captured map.

When reproducing these Italian maps, 512 Field Survey Company added new detail and revision from all available sources, including air photographs when the latter could be obtained. Work was also begun to re-compile the Italian 1/400,000 series into a new British 1/500,000 series covering the operational area.

The British offensive reached its extreme western limit in February, 1941, when El Agheila was occupied. Difficulties of supply over long lines of communication, and a reduction in available resources of personnel and equipment, owing largely to the necessity for sending an Expeditionary Force to Greece, made a retirement inevitable. Benghazi was evacuated early in April, and the Desert Force was back across the Egyptian frontier in the Sollum area by the end of that month.

Anxiety about the Greek mapping situation had been felt in the autumn of 1940 when the Italians crossed the Albanian frontier into northern Greece. The mapping work which was undertaken for the campaign, which opened in early April, is described in Chapter XII, Section 3.

Maps of Crete were reproduced in the Middle East and were available for distribution before the German invasion of that island. They included the following:—

- (a) A 1/300,000 map of the island, which was a reprint of GSGS 1896 incorporating some road revision. It was first printed in August, 1940. During the battle in Crete in May, 1941, when it looked as though existing stocks might not be sufficient, a second printing was carried out.
- (b) A 1/100,000 map in five colours covering the Heraklion area. This was printed in Palestine from black pulls of an original Greek map dated 1936, a name trace giving transliterated names, notes for the margins, and data from which to plot and incorporate the Crete grid. A small advanced stock was flown to the island, the remainder following by sea.
- (c) A 1/50,000 gridded series of 16 sheets covering most of the island exclusive of that portion covered by (b). This was a transliterated edition of the original Greek maps and was produced by a combination of redrawing on enamel plates and duffing out on the negative. An all-black edition was available in Crete for the initial fighting, and a final four-colour edition was produced by 17th May but, owing to the lack of both sea and air transport, very small stocks only of the latter reached Crete.

Maps of Cyprus were prepared as under:—

- (a) A  $\frac{1}{4}$ -inch map (GSGS 3974) was printed in May, 1941, from War Office reproduction material, with layers, grid, and revised roads.

- (b) Maps on 1/25,000 scale were produced by enlargement from the existing  $\frac{1}{2}$ -inch to 1 mile map. H.Q. British troops in Cyprus selected certain sheets and these were printed during May and June, 1941.
- (c) 1/50,000. To accelerate the production of a medium scale tactical map, it was decided to cover the island on 1/50,000 scale rather than on 1/25,000. 16 provisional sheets covering the whole island were produced in June, 1941, in black only. These were later replaced by a fully coloured edition.

The following maps of Palestine, published by the Palestine Survey Department, were in existence at the beginning of the war:—

- (a) 1/20,000 covering the coastal areas and the Plain of Esdraelon.
- (b) 1/100,000 covering all Palestine north of Lat.  $31^{\circ} 20'$ .
- (c) 1/100,000 (new large sheet series) in course of production, extending from Lat.  $31^{\circ}$  northwards and overlapping the lower sheets of (b).
- (d) 1/250,000 covering all Palestine.

The above were printed in one colour and were gridded. The preparation of revised sheets on 1/25,000 scale was put in hand at an early date, and this applied also to the 1/100,000 series. As a result of surveys carried out by the Australian Field Survey Company a 1/100,000 edition covering Transjordan was completed and published.

Before the start of hostilities in Syria the following maps of that country were in existence:—

- (a) 1/50,000. A coloured, hill shaded series which was in course of production by the French Service Géographique, covering the south coastal area, Damascus, Homs and Aleppo.
- (b) 1/100,000 series covering the coastal area. This was an enlarged, transliterated edition of the Turkish 1/200,000 series and was not kept up to date.
- (c) 1/500,000 series covering Syria and the Lebanon. This, again, was based on the Turkish 1/200,000.
- (d) 1/200,000 series covering the whole of Syria except for the north-central area. This map was based on proper surveys where available, the remainder being compiled from route surveys.

The principal early work on the maps of Syria which was initiated by the Survey Directorate was as under:—

- (a) Three sheets of a road diagram on 1/500,000 scale were produced in June, 1941, to cover the coastal belt.
- (b) A redrawn edition of the French 1/200,000 series west of longitude  $40^{\circ}$  was published in five colours. The remaining sheets were at first printed in black only, with coloured grid numbers. It was decided that, east of longitude  $40^{\circ}$  the sheets of this 1/200,000 series would be replaced eventually by the Survey of India  $\frac{1}{2}$ -inch sheets.
- (c) Reproduction of the French 1/50,000 series was begun by redrawing for a four-colour edition. After ten sheets had been completed the remaining 30 were reproduced as a provisional edition in two colours only, slate-blue detail with red road filling and grid, in order to expedite completion. They were later revised from air photographs and other material and were redrawn for reproduction in four colours.

Fuller details of the mapping situation in Iraq and Persia will be found in Chapter VII. Early production in the Middle East included the following:—

- (a) The 1/500,000 Iraq Desert series was reprinted in Cairo from War Office plates.
- (b) 20 sheets of the  $\frac{1}{4}$ -inch series covering the area from Mosul to Basra were printed from black pulls supplied by the Survey of India during the Iraqi revolt. Ten more sheets covering the area west of the Tigris into Syria were subsequently reproduced from Indian basic material.

The above brief summary gives a general idea of the mapping situation which presented itself to the Director of Survey, Middle East when he assumed responsibility for the area, and the work which he initiated to develop and improve it during the early months of the campaign. Further notes will deal with the principal mapping programmes which were later undertaken for operations directly controlled by G.H.Q., Middle East, for other potential operational areas, and for A.F.H.Q., on an agency basis in connection with the fighting in North Africa, Sicily and Italy, and for the operations in southern France in 1944.

#### **Temporary civilian mapping organizations**

Reference has already been made to the map production and printing resources available with the Survey Departments in Egypt and Palestine. Later on, after the cessation of Vichy French resistance in Syria, the Service Géographique de l'Armée at Beirut was available to augment these resources to a limited extent. In the early days, however, when there was a shortage of survey units in the theatre, temporary civil establishments were formed in Cairo and Alexandria from locally hired personnel and equipped with locally purchased or constructed plant. Both were capable of rapid drawing on enamel plates and the production of wet plate negatives. Their special use was for the reproduction in colours of captured or record maps.

#### **The Tura Caves**

As 512 Field Survey Company was the principal map production unit at the disposal of the Director of Survey, it was essential that it should be accommodated in a good and safe place. The first location, on the edge of the Heliopolis airfield, was considered too vulnerable. Arrangements were therefore made for the unit to be moved to some caves at Tura, about six miles to the south-east of Cairo, where their work would be carried out within the safety of the caves themselves. The task of preparation and improvement took a long time, and it was some months before the unit was working to full capacity at Tura. It remained there throughout the whole war period, suffering periodical inconveniences and delays due to roof falls, dust and other factors incidental to the conditions prevailing there.

#### **Revision Group**

With the prospect of large revision programmes having to be undertaken, a special Revision Group was formed in 512 Company. This worked in close touch with the R.A.F. Photo Reconnaissance unit and the Air Photo Interpretation unit. In the early days the group was fully occupied with the revision of maps required for urgent reprints but, as soon as arrears had been

overtaken, it was organized to work on a continuous revision basis, and for new map compilation. Arrangements were made also with the various commands of the Middle East to decentralize to them responsibility for the revision of certain map series and a system was evolved for the interchange of air photographs and other revision material.

### **The mapping situation in the autumn and winter of 1941**

Germany attacked Russia in June, 1941, and their rapid move eastward towards the Caucasus caused considerable strategic apprehension in the Middle East. This was aggravated by subversive activities in Iraq and Persia, German successes in the Balkans, and the British retirement from Libya back into Egypt. Uncertainty about Japan's future actions, and their possible repercussions on Middle East strategy, completed this somewhat gloomy picture. One bright spot on the credit side was the defeat of the Italian forces in Abyssinia and Eritrea, which removed the threat to the Sudan.

The effect of all this on the mapping policy of the Director of Survey, Middle East was considerable. The potential areas of possible operations had been widened, reinforcements which were arriving in the theatre in increasing numbers required to be mapped up, and plans were afoot for a new British offensive in the Western Desert. The latter started on 18th November, and was followed by a rapid advance into Cyrenaica and the reoccupation of Benghazi in December. This success was somewhat offset by the entry of Japan into the war, the invasion of Malaya and the fall of Singapore.

It would serve no useful purpose to enumerate in detail all the mapping work that was carried out to meet the actual or potential situations that arose or might have arisen as a result of the above happenings. As in all other theatres the work of the Survey Service included not only the revision and reprinting of existing standard map series, but also the preparation of new ones, and the production and printing of innumerable special maps, charts, diagrams and sketches required by various branches of the staff and services, and by field headquarters and formations. Reference will be made, therefore, only to the more important tasks which were handled by the Survey Directorates and units, with special notes, where applicable, on any special activities in the mapping sphere that were undertaken in connection with particular operations.

### **Second British offensive into Libya (November, 1941)**

In anticipation of this offensive, and for training purposes in Egypt, much new mapping and revision was carried out covering both Egypt and Cyrenaica. Big printing programmes were undertaken so as to build up large operational stocks. After the offensive had been launched, and while our troops were in occupation of Cyrenaica, much further mapping work was undertaken, both in the field and at G.H.Q.

The Normal and Western Desert 1/100,000 series of Egypt continued to be the principal tactical maps, and were reprinted with revisions. An important new project was the production of 1/50,000 maps from ground surveys in two areas of the desert. One of these, known as the Daba-Alexandria series, covered the important defensive area around El Alamein, just east of Daba, extending from the coast to the Qattara Depression (Plate 7). At the time that this work was proposed by the Director of Survey, the offensive westwards was proceeding so satisfactorily that there was some inclination on the part of the

General Staff to consider it unnecessary and a somewhat wasteful use of survey resources. The survey was, however, undertaken and, as subsequent events proved, the resulting maps were invaluable when the British Eighth Army was thrown back on the defensive and then turned to win the battle of El Alamein. The other area covered was further to the west in the Matruh-Daba area. Much of the ground survey was done by the South African Survey Company.

A new small scale series at 1/250,000 scale was taken up by G.H.Q. to cover northern Egypt and Cyrenaica, some of the sheets being compiled by survey units and others being done by the Egyptian Survey Department (Plate 8).

Large scale (1/25,000) sheets of the Egyptian Normal series were revised and reprinted for important areas such as the Delta, and further new sheets were produced by the Survey of Egypt. The 1/25,000 maps of the Matruh area (Plate 9), which had previously been compiled from air photographs, were revised on the ground by field survey units, and the Matruh defences were covered by a special defence map at 1/12,500 scale. In addition, numerous selected areas were surveyed and mapped at even larger scales for the development of camp sites, etc.

The entire 1/100,000 series of Cyrenaica was redrawn for reproduction in colour, and was published with recast sheet lines across the Egyptian frontier (Plate 10). Where revision material was available in the form of air photos or other material, it was incorporated. For Tripolitania the existing 1/100,000 sheets were reprinted with grid letter overprints.

Two special sheets on 1/50,000 scale covering the important frontier area between Egypt and Cyrenaica were produced, and were overprinted with information interpreted from air photographs. With an eye to the future, a pilot sheet for a 1/50,000 map of the Tripolitania area was put in hand during September, 1941, and several sheets were printed by December, so as to provide basic maps for overprints when the operations should reach there. The 1/50,000 maps of the Tobruk area which had been previously issued, were recast in three new sheets during October with defence overprints added. During March, 1942, it was decided to cover Cyrenaica by a standard 1/50,000 series, each sheet to be one quarter of the new 1/100,000 sheets. They were to be compiled from ground surveys and air photographs by the survey units serving with Eighth Army. Important tactical areas were, of course, given priority, such as Tobruk, Gazala, and other localities where fighting was in progress or anticipated.

On the smaller scales, sheets of the new 1/250,000 series covering Libya were in production at G.H.Q. in October, 1941, as also were some revised sheets on the 1/500,000 scale. On these latter special "Going" overprints were issued as an aid to the movement and operations of armoured units (Plate 11). When Eighth Army had, for the second time, reached El Agheila, all the resources of 514 Field Survey Company in the field were put on to the preparation of three 1/250,000 sheets in that area from photographs taken by 60 Squadron S.A.A.F., using control established by 514 Company.

Preparation of 1/25,000 maps of the Tripoli series started in September, 1941. Many special strip maps and mosaics from air photographs were prepared to meet urgent operational requirements, and defence overprints, revised at frequent intervals, were an almost daily requirement during critical periods of the fighting.

The survey unit available with Eighth Army at that time was 514 Field Survey Company R.E. which had attached to it a drawing section of 512 Field

Survey Company. The unit was equipped with mobile lorry-borne map printing equipment.

### **Mapping work in Palestine and Trans-Jordan**

During the period leading up to the clash with the Vichy French in Syria, the priority areas of Palestine from the mapping point of view were in the north, immediately south of the Syrian border, and in the eastern defence area along the Jordan valley running north from the Dead Sea. The existing 1/20,000 maps of these parts of Palestine, after reduction to the standard of 1/25,000 scale, were revised and printed. They were followed by further blocks of sheets along the coast, and in selected defence areas (Plate 14).

The survey resources at the disposal of the D.D. Survey, Military Forces in Palestine, during 1941 included 517 Field Survey Company R.E. with its mobile demy size reproduction equipment, and 2/1 Australian (Corps) Field Survey Company R.A.E. which was equipped with double-demy size machines mounted in trailers. In addition a detachment of the South African Survey Company was working in Sinai under the control of D.D. Survey, the 36 New Zealand Survey Battery R.A. was doing topographical survey work in Trans-Jordan under G.H.Q. control with a detachment in Cyprus, and a Royal Marine Survey Section became available late in 1941. Later on 13 Field Survey Company R.E. increased the survey resources with Ninth Army in Palestine. The Palestine Survey Department was available on an agency basis for carrying out limited programmes of map production and printing.

Field parties of the above units completed extensive ground surveys to establish control for new air-photo mapping for the revision of existing maps, and for plane-table surveys.

The existing 1/100,000 series of Palestine was periodically revised and, as a result of the combined resources of military survey units and the local Survey Department, a newly drawn series on this scale was begun, with recast sheet lines, the detail being compiled from a combination of ground survey and air photographs (Plate 12).

On the 1/250,000 scale two demy-size sheets covering Trans-Jordan were produced in August, 1941. These overlapped the Palestine series and, during the summer of 1942, a new series on this scale was produced covering both countries in five sheets of a size suitable for printing on the mobile demy machines of the field survey companies.

### **Syria**

Syria came within the responsibility of the D.D. Survey Ninth Army after its occupation, and the somewhat limited resources of the French Service Géographique at Beirut were at his disposal in addition to the survey units mentioned in the preceding paragraph.

When the Germans thrust deep into Russia towards the Caucasus, Syria assumed considerable importance strategically as an outer bastion of the Middle East theatre. As Turkey continued to remain neutral, the frontier between Syria and Turkey became one of great survey importance, and much ground survey and new mapping work was put in hand both along the above frontier and in various selected defensive areas which guarded the approaches from Iraq and Trans-Jordan.

On the tactical scales this work included 1/50,000 and 1/25,000 maps covering

the so-called fortress areas of the Jordan, Damascus, Ras Baalbek, Tripoli and Haifa, and also along the Turkish frontier. On the smaller scales the original Syrian 1/200,000 series, which had been reproduced in revised form, was partly replaced in 1942 by a new "Levant" series on the same scale. This carried bilingual names, and new 1/250,000 sheets of South Levant were completed in August, 1943. The 1/500,000 maps of the country were republished in a revised bilingual edition during 1942.

The map series that were eventually maintained for this area, apart from the large scale 1/25,000 of special areas, were:—

1/50,000	Levant (Plate 13).
1/50,000	South Levant.
1/100,000	South Levant.
1/200,000	Levant.
1/250,000	South Levant.

### Turkey

Although it became increasingly likely that Turkey would maintain her neutrality, that country still remained an area of great strategical importance in so far as maps were concerned. Possible action by Germany, as a result of operational successes in South Russia, might have involved the employment of British forces from the Middle East in the defence of Turkey against aggression, and it was therefore essential that maps should be available in case of need.

At the end of 1941 the Turkish 1/800,000 series had been reproduced in colour to form a small scale strategical map. Reproduction of the Turkish 1/200,000 series continued during 1941 and 1942, and sheets were revised as new detail material became available.

A few new 1/100,000 sheets covering Turkey in Europe were produced during 1943-44 as an extension of the Greek maps on the same scale. On the 1/25,000 scale the important areas of Istanbul and the Dardanelles were covered by colour separated reproductions from Turkish large scale maps. Names were transliterated and revision was incorporated.

### The Caucasus

This, being the frontier region between Russia, Iraq and Persia, became an area of great strategical significance when the German armies swept through towards the Caspian Sea. It was covered by a War Office 1/500,000 series which, in turn, was overlapped in the south by a  $\frac{1}{4}$ -inch series produced by the Survey of India. Reproduction of both these series was effected by Middle East Survey from material supplied by the two respective sources of origin.

### Malaya

At the beginning of 1942, following the Japanese invasion of Malaya, the Australian Corps was transferred from Middle East to the Far East, and had to be mapped up to meet possible contingencies. The following maps were reproduced and printed from material supplied:—

#### Malaya

1/250,000	North and south sheets of Johore and Singapore, first in a quick monochrome edition, followed by a coloured edition.
	1 inch to 1 mile Selected sheets.
	Motor Map (12 miles to 1 inch).

*Sumatra*

1/750,000 Selected sheets.

1/250,000 Selected sheets.

1/100,000 Selected sheets.

1/50,000 Selected sheets.

*Borneo*

1/200,000 Selected sheets.

*Java*

1/100,000 Selected sheets.

### Further miscellaneous mapping during 1942

*Aden.* A limited amount of new mapping was done. Ground control for Aden and its hinterland had been established between the two wars under War Office arrangements, and air photographs were taken during 1942. One sheet at 1/50,000 and two at 1/25,000 were produced by Middle East Survey.

*Crete.* During October and November, 1942, several of the existing sheets on scales of 1/400,000, 1/100,000 and 1/50,000 were revised from air photographs. Further work for this island was undertaken later in 1943.

*Cyprus.* The provisional 1/50,000 series in black only was replaced by a second edition in four colours. As there were many areas in the island where no contouring had been done, a survey party was sent to do this work so that the map series could be completed.

Further 1/25,000 sheets were taken up for production during 1942, and a revised edition of the existing  $\frac{1}{4}$ -inch map was begun.

*Malta and Gozo.* The maps of the island at 2 inches to 1 mile were reprinted using War Office reproduction material.

*East Africa.* Although the operations against the Italians were over, there was quite a big programme of new mapping being done by the East African Survey Group, and G.H.Q. Middle East took a share in the preparation of several of the new 1/500,000 sheets.

*Dodecanese and Aegean Islands.* These were still in enemy hands during 1942, but, in view of their considerable nuisance value in the Mediterranean, action to dislodge the enemy from them was being planned. A revised edition of Rhodes at 1/100,000 was taken up in November, 1942, also a new sheet to cover Scarpanto. Later, in 1943-44, the Dodecanese were covered by a newly compiled 1/25,000 series.

The original maps of the Aegean Islands, which were direct reproductions from record copies, were now being replaced by newly compiled maps from air photographs at a scale of 1/50,000.

*Italy.* Thoughts were directed to the mapping of Italy at an early stage, and pilot sheets at various scales had been prepared by G.H.Q., Middle East, during 1941 and early 1942.

The extensive programmes of Italian mapping which were taken up in conjunction with A.F.H.Q. during 1943 will be dealt with later.

### The Battle of El Alamein and the final Eighth Army offensive into Libya and Tunisia (Winter of 1942-43)

In January, 1942, Rommel and his Afrika Korps retook Agedabia, the extreme westerly limit of the British offensive in the autumn of 1941 and, after occupying Benghazi, thrust Eighth Army well back into Cyrenaica. There

followed a period of relative inactivity until May, 1942, when he launched his offensive, advanced to Bir Hakeim, and forced Eighth Army to withdraw into Egypt. By the beginning of July the enemy had passed Mersa Matruh and was thrusting forward towards Alexandria. By 6th July, however, the drive to the Nile had been stopped in the El Alamein area, and both sides were concerned with building up their strength and resources.

The survey units with Eighth Army were almost continually on the move during this period of withdrawal, and the mobile printing equipment of 514 Company was kept busy day and night turning out enormous quantities of maps, defence overprints and other requirements of that nature to meet the day to day operational needs of the force.

It is of interest to note that at a critical period when Eighth Army was on the defensive in the El Alamein area, the enemy planned a final stroke to thrust their armour through to Alexandria and the Nile delta. A faked "Going" map was prepared and deliberately allowed to fall into enemy hands. The map showed patches of "bad going" for armour along what was in fact the most favourable line for his advance, and "good going" along a route which would lead his armour towards concealed British defences where it could be adequately dealt with. According to prisoners' statements it seems probable that he fell for this ruse. In the event his force was so badly mauled during the battle of Alam Halfa in the first week of September, 1942, that it proved to be his last offensive action in that area.

In mid-August came the changes in the Higher Command when General Montgomery took over command of Eighth Army. From that moment all energies were devoted to preparations for an offensive which was to drive the enemy out of Africa. It was to be timed to take place more or less concurrently with the landing of Allied Forces in North West Africa.

Mapping preparations for this offensive were considerable and widespread. As the German threat to the Middle East through the south of Russia was still a real one the development of the mapping programmes for Palestine, Syria and Turkey had to continue unchecked.

514 Field Survey Company was withdrawn from Eighth Army to G.H.Q. control at the conclusion of the British retreat and was employed on track surveys and desert beaconing behind the El Alamein position and towards the south, the results of their work being incorporated in all relevant maps of the area.

Most of the map production work for the offensive was done by 512 Field Survey Company, which was the base production unit at the Tura Caves, and 46 South African Survey Company, to which a drawing section of 514 Company was attached, principally for work in connection with the location and plotting of enemy battery positions on block plots at 1/25,000 scale. These were specially prepared for the El Alamein battle and were used successfully by the counter-battery organization for concentrating artillery fire on to enemy gun positions and defence works before and during the battle.

It will be remembered that the Daba-Alexandria series of maps at 1/50,000 which covered the battle area had been produced from ground surveys some months previously. During the build-up period before the battle some further sheets were published, and overprints were prepared showing all known enemy positions, gun areas and other important detail. Between the beginning of August and the battle itself five editions were issued, each one bringing the information known about the enemy more up to date. These maps were distributed down to platoon commanders.

A special edition of three 1/25,000 sheets showed enemy defences in the area lying south-west of Tel-el-Eisa. The defences had been located on photographs taken with a 36-inch lens, and were positioned on the block-plots which covered the whole front. The positional accuracy of the detail was reckoned to be about  $\pm 20$  metres.

Special air observer maps were issued which showed only the main topographical details. Day bombers used the 1/250,000 scale, and the Photo Reconnaissance units and the Tactical and Strategic Reconnaissance squadrons used the 1/500,000 scale.

Apart from the above-mentioned and many other special maps which were prepared for planning and for the battle itself, large stocks of the standard series of maps covering the Western Desert and Libya were reprinted in revised editions for distribution and for assembly in the various map depots. Principal field survey units which were assigned to Eighth Army were the 46 South African Survey Company and 517 Field Survey Company R.E., each of which was equipped with mobile demy size printing equipment.

The standard maps took the Eighth Army through Libya as far as Agheila during its rapid advance. In anticipation of a battle there, demands for survey increased, and 46 South African Survey Company moved up near Army H.Q. and printed copies of the 1/50,000 sketch maps of Agheila and Agedabia which had been prepared during the previous offensive. They were the only maps of that area available on a scale larger than 1/250,000 but were unsatisfactory, being based on very limited ground control of dubious quality. The previous withdrawal of the British forces had prevented the completion of proper control surveys, and there was a considerable divergence of detail relative to the grid between the 1/50,000 and 1/250,000 maps. This caused a good deal of confusion and lack of confidence. It also pointed to the need for clear-cut action on the part of Survey regarding the control and gridding of maps at varying scales to ensure that the best available control material is used, and that the grid incidence of detail on maps of the same area at different scales is consistent.

Very little enemy map material was captured during the early stages of the offensive. One of the most useful finds was an index diagram of the Italian 1/100,000 series which indicated that, anyway as far west as Benghazi, no Italian sheets of this series were in existence which had not already been used in the preparation of the British map series.

As Eighth Army continued its advance into Tripolitania, the division of the map reproduction work between 46 Company and 517 Company became very unequal. 517 Company was back at Bardia and had little printing to do, as map stocks of Eastern Cyrenaica were adequate. 46 Company, however, was overwhelmed with repeated demands for overprints of enemy defences, etc. 517 Company was therefore moved forward to the Sirte area to assist 46 Company, and to prepare the 1/100,000 series of Tripolitania for printing on the mobile demy machines. At this time G.H.Q. supplied reproduction material to Eighth Army, in the form of kodelines, of four map series of Tripolitania, so that they could be self-contained and independent with regard to map printing. This became more and more essential as the lines of communication grew longer and longer.

By 23rd January, 1943, Eighth Army had captured Tripoli, and on 29th January, entered Tunisia. In anticipation of this the Army had assumed responsibility for printing in the field over 40 sheets of the 1/200,000 series of Tunisia in five colours. At the same time G.H.Q. Survey concentrated much

of its resources on Tunisian map production during January, work on Cyrenaica and the Levant being placed in abeyance.

During early January, 1943, one of the principal mapping tasks with Eighth Army was the production of 1/50,000 defence overprints of the Buerat area, and second editions of sheets which had been compiled from imperfectly controlled air photographs were issued before the attack on 15th January.

In addition to the Tunisian 1/200,000 series there was one at 1/100,000 but it was considered unsuitable for battle owing to its lack of clarity and the discrepancy in detail which was apparent between it and the 1/200,000 series. During February, therefore, Eighth Army survey units undertook the production of new 1/50,000 maps in the Gabes, Mareth and Medenine areas (Plates 15 and 16). These were considered necessary because the southern part of Tunisia had been only spasmodically mapped by the French at medium scale, their 1/50,000 series ending about the latitude of Sfax. It was, in any case, inconvenient to use the French native sheet lines as they were too big for the mobile demy machines.

By mid-March Eighth Army was on the Mareth Line. There was a demand for new 1/25,000 maps of the Mareth Line proper but, owing to pressure of work and insufficient resources, this could not be met. As a compromise, certain portions of the 1/50,000 maps were enlarged to 1/25,000. For the battle itself a special 1/12,500 sketch map was made up and, for the New Zealanders' turning movement round the Matmata Hills, a special edition of the 1/100,000 sheets was issued. During the ensuing fighting through southern Tunisia the survey units turned out new maps from air photographs wherever it seemed likely that the enemy would stand.

For the last phase of the operations between Sfax and Cape Bon, Eighth Army was using principally the Tunisian maps at 1/50,000 scale. These were printed in the field from kodelines supplied by G.H.Q., and air-photo revision was incorporated where obtainable. Enlargements to 1/25,000 of the French 1/50,000 sheets were also used, with the British (North African) grid overprinted. The infantry liked to have the larger scale map as it gave them more space for inserting local detail and notes.

Hostilities ceased in Tunisia on 12th May, 1943, and the long and arduous struggle to keep Eighth Army supplied with maps for their African campaign came to an end.

### **G.H.Q. mapping in the early part of 1943**

The strategic outlook in the Middle East underwent a considerable change during January and February, 1943. There were firm indications that the days of the Axis forces in Africa were numbered as a result of Eighth Army's victorious advance from Egypt to Tunisia and the eastward drive of the British and U.S. Allied Force in North West Africa.

In Russia, Stalingrad had been relieved at the end of November, 1942, and the tide definitely turned about the end of February when Russian armies began to drive the Germans westwards.

These events materially affected strategical mapping policy and G.H.Q. Survey then took up urgent mapping programmes for future operational areas. As the advance of Eighth Army proceeded further and further to the west, there arose demands for maps covering areas well outside the original geographical boundaries of the theatre. The next move, after clearing the enemy out of Africa, was to pave the way to a landing on the

mainland of southern Europe by eliminating, one by one, the obstacles that lay in the way. Map production for Sicily, Sardinia and Corsica was put in hand using War Office reproduction material. Greece, Crete, and the Aegean and Dodecanese Islands were also taken up. Some of this work was reproduced from War Office material, some was new mapping from air photos. Mapping of Italy itself was included, and these programmes were co-ordinated with the Survey Directorate at A.F.H.Q. which would be responsible for the conduct and control of the operations. Owing to the immense scope of the task the maps were at first prepared for one-colour printing wherever possible, with the intention of clarifying them by the use of colours and adding further revision as opportunity offered later.

G.H.Q. Survey concentrated 13 and 514 Field Survey Companies and drawing sections from 19 Field Survey Company at Abbassia to contend with the increased work. On the printing side May, 1943, provided a record with an output of over 2,000,000 maps. This record was, however, well beaten during June when the monthly output soared to 4,000,000.

### The invasion of Sicily ("Husky")

The general arrangements and organization set up by D. Survey, Middle East to plan and execute the mapping preparations for this operation have been described in Section 1. Further details regarding the survey side of the operation will be found in Chapter XII, Section 4.

The Allied force which took part in the assault was under A.F.H.Q. command, and various portions of it were mounted respectively in the United Kingdom, the United States, North West Africa and the Middle East. Maps had therefore to be printed and distributed in all the above mounting areas.

These notes refer to the actual mapping work which was undertaken in the Middle East itself. The maps which were required and the material from which they were reproduced were as under:—

1/M International Series.	Material already in Middle East.
1/M Plotting Series for Air Navigation.	"    "    "    "
1/500,000 air map in colour.	Black pulls of all colours from the War Office.
1/250,000 in colour.	Kodalines of all colours from the War Office.
1/100,000 in colour.	(a) Black pulls, all colours. (b) Kodalines, all colours, from the War Office.
1/50,000 "Griblet" style.	Kodalines for the basic map and grid from the War Office Black pulls for red and blue overprints from the War Office.
1/25,000 "Griblet" style.	As for the 1/50,000, except that the grid was on the basic map.
Town plans.	

The kodalines and black pulls were sent out from London by air as they became available. Some of this material arrived somewhat late during the production period. It was found that a combination of black pulls and

kodalines for any one map proved most difficult to assimilate. Many methods were tried by the survey units engaged on the work but, in the case of this mixed material, the quickest practical method was found to be to redraw the red and blue detail. In the case of the 1/25,000, time and resources did not allow of this being done for the blue detail, so they were therefore printed in brown and red only.

The black pulls of the 1/100,000 series were uneven in size, so printing was held up till the kodalines arrived. These were found satisfactory, as also were those for the 1/250,000 series.

The general recommendation as a result of experience on this job was that for any future operational planning of a similar nature, all reproduction material should be supplied in kodak form if the necessary amount of film is available. With modern improvements in the manufacture of low-distortion film, and the introduction of improved methods for film duplication, there seems little doubt that this recommendation was a correct one.

For the 1/500,000 series, which was a comparatively coarse map for air use only, the black pulls were found to be satisfactory.

It was intended that for the 1/250,000 and larger scales, the sheets should be of demy size. In most cases the demy sheets, as sent out from the War Office in the form of kodalines, were arranged in pairs on the film so as to enable printing to be done directly on double-demy machines. This was a good arrangement, allowing full and direct use of the machines available in the Middle East.

In spite of the difficult climatic conditions prevailing, it was found that, over a long period, the small (demy) machines belonging to the field survey companies could turn out 500,000 impressions a month, and the larger (double-demy) machines could reach an output of 700,000 impressions. At peak periods as many as 30,000 impressions a machine each day were obtained.

When planning for "Husky" first started it was comparatively easy to introduce some form of mapping "cover" as a security measure, as at that time Middle East was engaged on the mapping of areas such as Greece, Crete and elsewhere. Later on, however, it became more difficult. There were delays due to the late arrival of mapping material from London, the need for local revision of the maps from air photos which came in much too late, and the shortage of labour and printing paper. During the last few weeks before "D"-day the survey "cover plan" practically ceased to operate, as all available men and machines had to be concentrated on the Sicily maps to the exclusion of all other work. This was probably unavoidable and no doubt occurred in other theatres during urgent last-minute spasms before a specific operation, but it does not affect the general principle that, wherever possible, security must be guarded to the utmost extent by having concurrent work in progress for other areas. And yet, so far as is known, there were no lapses of security on the part of the survey personnel employed on this mapping work.

At the last moment there was an urgent demand for the printing of chart maps for the Royal Navy. These were to have been supplied originally in bulk by the Admiralty. Owing to a hitch in the supply channels, however, they were despatched to the Middle East too late, but fortunately the Director of Survey at the War Office had foreseen the emergency and had sent out by air the necessary reproduction material which enabled stocks of the chart maps to be printed locally and supplied to the Navy in time for the operation.

Early planning indicated that there would be a requirement for a series of defence overprint maps on 1/25,000 scale all round the coast from Catania to Licata. The standard 1/25,000 sheets were of demy size and, as there were approximately 60 of them, for which 18,000 copies of each were required, this represented a formidable printing project. They were therefore made up into 18 double-demy sheets, thus effecting a considerable saving in printing time. Three planning editions of these defence overprints were published between 1st May and 4th June, and the fourth (final) edition for the operation itself was issued on about 1st July. This latter edition gave the latest possible information about enemy defences in Sicily.

There were some interesting and useful lessons to be learnt from the arrangements made for the production of these overprints. The "defences" information was compiled in the form of two traces by officers of the Middle East Interpretation Unit (M.E.I.U.), who examined the air photographs of the area and interpreted the detail. One of these traces showed topographical information which was not already indicated on the base map itself, and included such general annotations as "Vineyards," "Olive Groves," etc. The other showed details of the enemy defences. These two traces for each map sheet were prepared by different officers, who were often not in contact with each other. The result was that, when they were superimposed for printing, the detail on one fouled that on the other. Another defective arrangement was the fact that the basic maps supplied to the interpretation officers, from which they made their overprint traces, were of slightly different size from the final printed copies. This caused much wasted time due to faulty register, and could have been avoided by more careful survey supervision of the job as a whole. It is essential that, if they do not do the work themselves, Survey should issue clear technical instructions to units such as M.E.I.U., or other similar interpretation organization, who may be undertaking the preparation of defence or similar overprints for which Survey will be responsible for subsequent printing.

The overprint information was printed in two colours, except in the case of the final edition where three colours were used. The arrangement was:—

- (a) *Green*, for the topographical overprint which consisted mainly of topographical annotations such as "Vineyards," etc.
- (b) *Dark blue*, for enemy defences.
- (c) *Black*, for last-minute additions to either of the above.

It seems probable that most of the green notes were superfluous. Those that were considered to be of vital importance could probably just as well have been included in the "blue" overprint. The last-minute additions might also have been included in the "blue" printing, and this would have been less confusing to the user. The saving in colours would have cut down the printing time by a considerable amount.

Special maps, showing such things as airfields, water resources, "going" conditions, etc., were asked for in considerable numbers and variety. These demands came in late and had to be cut a great deal as practically all the survey printing resources were required for the defence overprints.

During the initial preparation of the mapping material, the War Office had carried out a certain amount of revision, but this could only be made up to 1st April, 1943, in view of the fact that the reproduction material had to be distributed over a wide area to the overseas survey organizations sufficiently far in advance for them to reproduce and print the maps. By that date there was

only a limited quantity of air-photo cover available, so the amount of revision possible by the War Office was somewhat scanty. Subsequent to 1st April some further air-photo cover became available to A.F.H.Q. and Middle East, and revision was put in hand locally in both places.

The survey photo supply situation for the revision of the maps for "Husky" afforded many useful lessons. With a force the size of that employed on this operation, the map printing programme was extensive and took a long time to complete. When preparing for a big operation it is desirable that, at the earliest possible stage, a decision shall be reached by the planning staff of the areas over which new mapping from air photos or revision will be required, and arrangements made, and implemented, for survey photography to be undertaken without delay. The photographs should be in the hands of Survey sufficiently far in advance of the date of the operation to enable the best use to be made of them. Where the mapping material is being initially provided by a central body such as the War Office, the ideal to aim at is that the photographs shall be in the hands of that central body early enough for them to incorporate the revision before they distribute the reproduction material. In the case of "Husky" much of the photography was undertaken too late for any useful work to be done.

#### **The final phase (August, 1943–May, 1945)**

After the invasion of Sicily until the end of the war in Europe, mapping activities in the Middle East were concerned principally with the following:—

- (a) Map production and printing on an agency basis for A.F.H.Q.
- (b) Continuing the mapping programmes for Turkey, Palestine, Syria, the Lebanon, and Trans-Jordan.
- (c) Map preparation for all other possible operational areas within the theatre, *e.g.*, the Greek Islands and the Dodecanese, Greece, Crete and the Balkans.
- (d) Local map production for training and defence purposes and for staff use.

Air revision work for A.F.H.Q. was held up during July owing to a breakdown in the arrangements for supply of air photographs, but the situation improved in August. The general principle at that date was that Middle East Survey prepared revision models conforming to a specification laid down by A.F.H.Q., the latter undertaking the actual production of the revised sheets. In September, however, it was decided to revert to a system whereby Middle East prepared the revised kodalines for all sheets on which important revision was necessary.

This large scale revision programme had to be drastically cut when, in preparation for operations in the Dodecanese, all available mapping resources were concentrated on this new operational area.

In November, 1943, the bulk printing programme of the 1/M and 1/250,000 maps of Italy was accelerated, and printing of all the 1/100,000 sheets of Greece was undertaken. By January, 1944, the Dodecanese operations being over, resources could again be concentrated on printing and air revision for A.F.H.Q., including the preparation of maps for possible use in the Balkans, south-eastern Europe generally, and Turkey.

It may be of interest here to quote the system on which the large scale

maps of Italy and southern France were classified for revision purposes by the Air Survey Group in Middle East:—

*Class "A."* Very important revision required.

This was used for sheets containing areas of unsound planimetry.

New control was supplied by the Air Survey Group.

*Class "B."* Normal revision required.

"Normal" implied that the planimetry was sound, but revision of military importance was needed.

*Class "C."* No revision required.

In this case photos showed only minor differences from the map.

An example from areas in northern Italy and southern France will show how this worked out in practice:—

	<i>No. of Sheets</i>	<i>Classification</i>		
		<i>A</i>	<i>B</i>	<i>C</i>
1/25,000 Italy (North)	44	—	17	27
1/25,000 France (South)	63	—	14	49

In March, 1944, when A.F.H.Q. was planning for the assault landing operation ("Anvil") in the south of France, they asked Middle East to assist in the printing of cushion stocks involving over 30,000,000 impressions. Middle East offered to print about 13,000,000 for them and, during this intensive programme, 512 Field Survey Company on one occasion exceeded half a million impressions in a 24-hour period. 512 Company and 17 Map Reproduction Section between them turned out over 11,000,000 impressions in 30 days' work.

The maps of France required by A.F.H.Q. included:—

1/25,000, based on the French 1/20,000 where they existed, otherwise new mapping from air photographs.

1/50,000, reproduced from the modern series at that scale which the French had published along their eastern frontier areas.

1/100,000 sheets which had been newly produced by the War Office and the Army Map Service (A.M.S.) Washington.

### Maps of the Balkans

Before the shape of the final operations in Europe was clearly determined there was a possibility that Allied forces from the Mediterranean theatre might operate through the Balkans into Germany. For the purpose of this history, the Balkans will be taken to comprise Greece (including Crete and the islands of the Aegean), Albania, European Turkey, Bulgaria, Roumania, Yugoslavia and Hungary.

The mapping responsibilities of the Directors of Survey at A.F.H.Q. and the Middle East included between them, therefore, those areas of the above territories which it was considered might become potential operational zones. The Director of Survey at the War Office, with his comprehensive strategic mapping responsibilities, had undertaken with his resources in the United Kingdom the preparation and publication of certain Balkan series, A.F.H.Q. and Middle East supplementing these by local publications, and revising them. The War Office publication "Notes on Maps of the Balkans (July, 1944)" describes the G.S.G.S. series of that area which were available together with

some of those published by A.F.H.Q. and Middle East. Most of the map series so described were reproduced identically in the United Kingdom, at A.F.H.Q. and in the Middle East. This was made possible by the distribution by air of kodachrome films for each colour plate. Thus forces which might be despatched from widely separated bases could be identically mapped up.

All the principal British-produced maps of the Balkans at scales of 1/500,000 and larger carried the British Military Grid. There were certain provisional series which, being direct copies of foreign originals, were not so gridded. In selected areas the Admiralty Hydrographic Department produced charts carrying the British grid which were thus in sympathy with the army maps in that respect.

The Mediterranean and Balkan areas were covered by the following grid zones (see Diagram 2, page 112):—

- (a) *Mediterranean Zone*, covering Greece, most of Albania, the extreme south-east of Yugoslavia, Turkey, southern Bulgaria, the Greek Islands and the Dodecanese.
- (b) *Danube Zone*, covering eastern Yugoslavia, northern Bulgaria, Roumania, eastern Hungary, eastern Czechoslovakia, and the extreme northern tip of Albania.
- (c) *South Italy Zone*, covering southern Italy.
- (d) *North Italy Zone*, covering northern Italy, north-western Yugoslavia, and parts of southern Austria and western Hungary.
- (e) *Nord de Guerre*, covering the northern part of Austria and north-western Hungary.
- (f) *Crete*, covering only the island itself.

The principle of retaining local name-forms on maps was accepted for the preparation of all British- and American-produced maps. This had, amongst other advantages, the merit of affording consistent treatment as between maps redrawn *ab initio* and those reproduced by direct photographic methods from foreign originals. There are always, however, large numbers of foreign topographical terms, or abbreviations of them, on foreign maps, with which the average map user is not acquainted, and this was perhaps more in evidence in the Balkans than elsewhere in Europe on account of the diversity of languages. Many of the Balkan map series, therefore, carried brief marginal glossaries of the most commonly occurring abbreviations and topographical terms. Fuller glossaries were prepared for most of the Balkan countries by the Permanent Committee on Geographical Names (P.C.G.N.), assisted in some cases by the War Office.

For the principal Balkan countries gazetteers were prepared and published, mostly by the Survey Directorate in Middle East, one or two, however, being the work of the P.C.G.N. or the War Office. These gazetteers gave grid references except in the case of those of Greece and Albania in which the references were generally given in geographical co-ordinates.

One important requirement in the case of 1/250,000 maps, and those tactical maps on a larger scale which may be used for road movement purposes, is the classification of roads into width and surface categories. There is, unfortunately, no standard military datum by which to refer to these road qualities. A basic datum which applies to one zone of operations is probably not suitable for another, where the ground conditions and possibly the character of the operations themselves may be different. In any case the available data are often

entirely dependent on the information given on the local foreign maps themselves which makes it almost essential to adopt the same system or something very like it.

As a result the road classifications shown on the various map series of the Balkans varied from series to series. The details of these categories and the symbols by which they were shown were, of course, given in the marginal footnotes and conventional signs, and they were clearly illustrated in the "Notes on the Maps of the Balkans."

Most of the systems of width and surface classification were generalizations of, and were based on, local information and experience, and this inevitably resulted in some errors. For example, the system used for Hungary was based on a combination of intelligence reports, personal experience of individual roads, information from ground photographs, articles in technical journals, etc. All these data had to be collated into terms of the local system of classification appearing on the original maps of Hungary so that width and surface values could be allotted.

As a general principle, classifications given on military maps should wherever possible be checked by reconnaissance, and should never be regarded as more than a general guide. In the case of map series published by the War Office, most of the road classification systems were formulated by M.I. 10(c), the War Office Section concerned with such information. The Greek and Turkish systems were formulated by Military Intelligence (Topographic) in Middle East.

No attempt will be made to describe in detail all the series that were prepared or published to cover the Balkans. It will suffice to indicate in general terms some of the more important. They are grouped according to scale:—

(a) *Small Scale 1/1,000,000.*

- (i) GSGS 2758. Based on the International 1/M Series with standard sheet lines. This map was mainly for topographical "form at a glance" and for use as an air map. For this latter purpose it became standard practice during the latter part of the war to print the layer tints in shades of purple instead of the normal browns and greens, so that they would show up better under the special lighting conditions within the aircraft.
- (ii) MDR 1. This was a special 1/M series produced by the Survey Directorate in Middle East covering the Balkans with slightly different sheet lines from GSGS 2758. Towards the end of the war in Europe the GSGS series in its revised form was adopted for general use.
- (iii) GSGS 4257 (Russia). This was reproduced from a fairly modern Russian map and was layered similar to GSGS 2758. It overlapped the latter over Roumania and Hungary. This was a War Office series and was not published in Middle East, though small stocks were available both at A.F.H.Q. and in Cairo for wall map and other study purposes.

(b) *1/500,000.*

- (i) Europe (Air) GSGS 4072. This was the standard "Air" series designed specifically for navigational use. It covered nearly the whole of Europe, and was the only homogeneous series which embraced the whole of the Balkans. The detail being very generalized, limited its scope for military use.

- (ii) MDR 580. This was not published as a War Office series and was a local Middle East production made up by direct reproduction from the original drawings for the 1/M series (MDR 1) referred to above. It was replaced by the standard series GSGS 4072 for all sheets except a very few covering Turkey in Asia.
- (c) 1/250,000.

Except for Turkey, for which a 1/200,000 series was used, there were five principal series covering the Balkans at the 1/250,000 scale. All these were designed to join up with each other so as to provide continuous map coverage of the whole area suitable for strategical use and as road maps. Moreover the four series covering Greece, Bulgaria, Roumania and Yugoslavia were finally produced in identical style which showed topographical information as under:—

- Black. Towns, place names, railways, and grid.
- Red. Roads.
- Blue. Rivers and river names.
- Green. Woods.
- Brown. Contours.

The shape and size of the sheets were such that the sheet lines were closely related to those of the larger scale basic map material of each country, a fact of obvious value and convenience.

These 1/250,000 Balkan series extended northwards to the 47° N. parallel where, like the 1/100,000 series, they joined up with the standard series on both those scales covering Central Europe which were in use by the Allied Expeditionary Force engaged on operation "Overlord."

They were all published in Army/Air style with purple layers, accentuated railways, and strong water colouring. From the military point of view, the maximum amount of detail consistent with clarity at this small scale was shown on the maps. Names were transliterated in the case of Greece, Bulgaria and southern Yugoslavia. All were gridded with the British Military Grid.

Except in the case of Greece, few air photographs were available for checking or revising topographical detail during the initial stages of preparation from the foreign maps. It was therefore to be expected that when such photos did become available, a thorough inspection would reveal considerable alterations to roads, railways and woods.

The individual 1/250,000 series and a few features regarding their preparation are now given.

*Greece.* MDR 630/GSGS 4410.

Part of Greece was originally covered by a War Office series (GSGS 4088) which was issued for the Greek operations in 1941 (see Chapter XII, Section 3) and was found unsatisfactory. This new series, except for the War Office sheets of Crete, was produced in the Middle East, and was compiled from the latest available Greek 1/100,000 maps and various large scale maps of the Dodecanese and Aegean Islands, Italian maps of southern Albania, and the Yugoslav 1/100,000 series. It was subsequently republished by Middle East after revision from air photos and other information.

*Bulgaria.* MDR 633/GSGS 4412.

Compiled and published by the War Office, principally from Bulgarian 1/40,000 and 1/126,000 material.

*Roumania.* MDR 635/GSGS 4375.

Compiled and published by the War Office from the Roumanian 1/100,000 maps, Bulgarian maps, and the Yugoslav 1/100,000 series.

*Yugoslavia.* MDR 634/GSGS 4413.

Compiled and published by the War Office using Yugoslav 1/100,000 maps as basic material. In the north this series covered Hungary, for which part Hungarian 1/200,000 and 1/75,000 originals were used.

*Italy.* MDR 300/GSGS 4230.

Though Italy was not included in the Balkans area, a part of this series covered the north-western tip of Yugoslavia. Middle East did a lot of work in connection with the revision and reproduction of this series.

*Hungary.* The southern half was covered by the Yugoslav series (see above). The northern half lay within GSGS 4346, the Central Europe series published by the War Office (see below).

*Central Europe.* GSGS 4346.

This series was prepared for operations in Europe in connection with operation "Overlord." For that part which included northern Hungary and northern Roumania it was produced by colour separation from the relevant Hungarian and Roumanian 1/200,000 originals and was not redrawn.

(d) 1/200,000.

The principal map on the 1/200,000 scale in the Balkan area was that of Turkey, viz. MDR 3/GSGS 4193. This was originally published by Middle East direct from Turkish originals on the same scale.

The War Office produced a two sheet map on this scale covering the whole of Albania.

(e) 1/100,000.

The entire mainland area of the Balkans, as far north as Lat. 47°, was planned to be covered by four principal 1/100,000 series, viz. the Greek, Yugoslav, Bulgarian and Roumanian. To the north of Lat. 47°, Hungary and Roumania were included in the Central European 1/100,000 series. The War Office policy was first of all to reproduce by colour separation method from record copies of the foreign series without alteration, in order to provide provisional map cover, and then to follow up with a revision of those areas specifically required. There were no Bulgarian 1/100,000 original maps available as basic originals.

Crete and the Aegean Islands were not included in this 1/100,000 project.

The principal 1/100,000 series were as under:—

*Greece.* MDR 356 & 610/GSGS 4439.

MDR 356 was first produced by Middle East by direct reproduction from Greek maps, the only alteration being that the place names were transliterated. A newly drawn series (MDR 610) with detail revised from air photos was then produced by Middle East on

the same sheet lines. These two series replaced the original War Office publication (GSGS 4087) of northern Greece which had been issued in 1940-41.

*Bulgaria.* 1/126,000. MDR 650.

Though not at 1/100,000 scale, this map is included within this category as it was produced by Middle East as a "stop gap" until something better could be prepared. It was a one-colour direct copy of the Bulgarian sheets and was ungridded.

*Bulgaria.* MDR 654/GSGS 4444.

This was in production at the War Office and was a newly compiled redrawn map based on Bulgarian 1/40,000 and 1/126,000 material where such was available. A certain amount of intelligence information was incorporated as revision, but only a few sheets were actually published.

*Roumania.* MDR 627/GSGS 4417.

Middle East originally published a monochrome edition by reproduction from the Roumanian 1/100,000 maps. The War Office then took up direct colour separation reproduction from the Roumanian sheets. They carried no revision.

*Yugoslavia.* MDR 621/GSGS 4396.

A monochrome reproduction (MDR 604) of the Yugoslav 1/100,000 series was completed by Middle East during the winter of 1942-43. The War Office meanwhile undertook colour separation and the distribution of reproduction material for full colour printing. Responsibility for maintenance of the series was delegated to Middle East. The latter subsequently carried out revision and improvement work for A.F.H.Q.

*Hungary.*

This was partly covered by the Yugoslav, and partly by the Central Europe 1/100,000 series.

*Central Europe.* GSGS 4416/AMS.M 671.

The southern portion of this series covered the northern parts of Hungary and Roumania, and for those areas was based on Hungarian 1/75,000 and Roumanian 1/100,000 material. It was a newly drawn map compiled by A.M.S., Washington.

*Rhodes.* MDR 341/GSGS 4161.

*Scarpanto.* MDR 341/GSGS 4168.

These two sheets were compiled in Middle East using as a basis the 1/25,000 sheets covering the islands. They were brought up to date from air photos.

*European Turkey.* MDR 626/GSGS 4467.

These sheets were produced as an extension of the Greek 1/100,000 series referred to above. The basic material was the old Russian-Bulgarian 1/126,000 map, supplemented by 1/25,000 maps for the Dardanelles and Istanbul.

*Italy.* 1/100,000 MDR 540/GSGS 4164.

As in the case of the Italy 1/250,000 series, the only reason for including this in the Balkan area is because it covered the extreme north-western tip of Yugoslavia.

(f) 1/50,000 and larger scales.

As described above, the Balkan area was primarily covered by a uniform homogeneous series, country by country, on the 1/250,000 scale, with a heterogeneous collection of 1/100,000 series for most of the area. Consideration will now be given of the principal topographical maps on larger scales, some of which were supplementary to the 1/100,000 series, and some to fill gaps where no 1/100,000 maps existed.

*Crete* 1/50,000. MDR 612/GSGS 4426.

This was originally produced by Middle East from Greek maps and covered all but the eastern end of the island. Names were transliterated but it carried no revision. Subsequently Middle East published a revised edition from air photos including new sheets for the eastern end of the island compiled from a German 1/100,000 sheet and air photographs.

*Aegean Islands* 1/50,000. MDR 611/GSGS 4468.

This series, which covered nearly all the Greek Islands of the Aegean, consisted of sheets newly compiled in Middle East from air photos where such were available. They were contoured, and carried a red road classification overprint. Where no photos were at first obtainable, local charts were used, the result being of doubtful accuracy. They were later replaced by maps systematically compiled from air photographs.

*Albania* 1/50,000. MDR 639/GSGS 4477.

This Middle East publication covering the whole country was initially a direct copy of the Italian 1/50,000 originals. A revised and gridded monochrome edition of certain sheets was subsequently published early in 1944 using air-photo cover which then became available.

*Bulgaria* 1/50,000. MDR 657/GSGS 4449.

This was a War Office production obtained by colour separation from the modern Bulgarian 1/50,000 series with names transliterated. Only a very few sheets reached publication stage. As a "stop gap," Middle East reproduced direct from the Bulgarian 1/40,000 series. It was an unreliable map, especially with regard to communications, but was better than the 1/126,000 series which Middle East had also reproduced as a "stop gap" issue.

*Yugoslavia* 1/50,000. MDR 638.

A few isolated sheets were prepared by Middle East by direct enlargement from the 1/100,000 sheets.

*Istanbul* 1/25,000. MDR 629/GSGS 4470.

A block of old Turkish 1/25,000 maps was reproduced by Middle East by colour separation, the names being transliterated.

*Dardanelles* 1/25,000. MDR 624.

Over 60 Turkish maps were copied by Middle East to cover this area, and revision was incorporated.

*Yugoslavia* 1/25,000 (Med. 1).

The sheets of this series, which cover the Dalmatian Islands between Split and Dubrovnik, were prepared by A.F.H.Q. They were newly drawn, and were based on Yugoslav 1/100,000 originals,

which were enlarged and extensively revised during the course of drawing.

(g) *Town Plans.*

As in all other operational theatres there was a big demand for town plans, which are of special value for administrative purposes after occupation. Many of these were produced for the Balkan area, some by the War Office and others by Middle East, from a variety of basic material. Some were direct facsimile copies of existing plans, some were redrawn from the best material available, others were new compilations from air photos. In addition to those which were actually printed and published, record copies of plans for many other towns were held so that they could quickly be reproduced if the necessity should arise.

(h) *Through-way Town Plans.*

These special volumes were prepared by the War Office. They were intended to assist drivers to find their way quickly and directly through a town, and showed only the principal roads, buildings and other topographical features that would assist to this end.

They covered only Yugoslavia, Albania and Hungary. For the former the plans were prepared mainly from Yugoslav 1/100,000 maps, with added information from air photos. For Hungary the plans were produced from a Hungarian through-route publication and, where photos were obtainable, they were brought up to date and revised.

(j) *Miscellaneous.*

*Communications Maps.*

Several special maps were published either by the War Office or Middle East to show road, rail, and water communications. They were principally on a small scale varying from 1/2M to 1/400,000.

As part of a general European series the War Office prepared a communications map on a scale of 1/800,000 showing, on a brown topographical base, roads in red, railways in black, and navigable waterways in strong blue. The changes could be rung on the colour plates so as to present the required information either singly or in any combination.

*Air Maps.*

The maps available for the air forces in the Balkan area were the same as those in other theatres:—

- (i) The standard army maps, or the army/air style, for the tactical air forces operating in conjunction with the ground forces. This comprised the 1/M Army/Air, the 1/250,000 series, and, in some cases, even larger scales such as the 1/100,000 or 1/50,000.
- (ii) Air maps proper, which included the Europe (Air) series at a scale of 1/500,000 (GSGS 4072) which covered nearly the whole of Europe; the Middle East 1/500,000 series, which was eventually superseded by GSGS 4072; and Europe (Air) 1/250,000 (GSGS 3982). This latter covered only small areas of Yugoslavia, Hungary and Albania; over the rest of the Balkans there was no special air map at 1/250,000 scale, and the standard army/air map was used.

Maps for special navigational use were published by the War Office for the Balkans as for other operational areas. These included

the 1/2M and 1/M Plotting Charts. There were also the Lattice Maps on which "lattice" curves were overprinted for use in connection with radar aids to navigation.

Finally there were "Target" maps, which were prepared in special design and colouring for night bombing use, usually on a scale of 1 inch to the mile.

- (iii) Geological Maps, which were obtained from copies of foreign geological maps held by the Geological Survey in London from which the War Office prepared facsimile reproduced copies for Albania, Roumania, Yugoslavia, Hungary, the Central Balkans and the Middle Danube. Geological maps are of great value during the planning stage for an operation, when considering such things as water supply and suitability of terrain for airfield construction.

### SECTION 3. AIR SURVEY PHOTOGRAPHY

At the beginning of the Middle East campaign there was no provision for supplying air survey photographs but at a later stage, mainly as a result of the work of a squadron of the South African Air Force, and 1434 Flight R.A.F., large numbers of photographs were taken for and used by Survey for mapping, revision and other purposes. The R.A.F. were so preoccupied with their primary operational tasks for which they had insufficient resources, that they could do little about survey photography.

Much credit is due to the pilots of 60 Squadron S.A.A.F., 1434 Flight R.A.F., and other units who "delivered the goods" in spite of all handicaps, difficulties and hazards. Much of the photography was obtained by using aircraft of a type quite unsuitable for survey photography in operational areas against enemy opposition and which, owing to the small number available, could not be grounded sufficiently for proper maintenance.

The earlier that survey photography could be undertaken, before the enemy had built up his fighter opposition and anti-aircraft defences, the easier and quicker could it be obtained.

Experience in many theatres showed that this aspect of the problem was not fully appreciated in spite of constant representation by the General Staff and Directors of Survey. It is, of course, for the R.A.F. to say what type of aircraft is capable of carrying out operational photography for survey purposes, but it may be well to outline the general requirements for the Middle East:—

- (a) Aircraft whose performance would give a good prospect of survival in long straight flights over enemy territory.
- (b) Long serviceable endurance.
- (c) Minimum crew of two.
- (d) Cameras giving a large-size picture and having between-lens or louvre shutters.
- (e) Focal length of lens suitable to give a scale of about 1/30,000 at the selected flying height.
- (f) Vertical photography, with tilts not exceeding 2 degrees off the vertical.
- (g) Unbroken stereoscopic overlaps and no crabbing.

It was only during the final stages in the Middle East operations that really suitable aircraft were provided in the shape of two Mosquitoes. These were excellent for survey photography but two machines were insufficient.

During the period from March, 1940 to June, 1941, which included the first British offensive into Libya and subsequent retirement back to Egypt, there was no properly flown survey photography. Obliques taken with tilts up to 15 degrees off the vertical were taken by fighter aircraft and, after rectification, were used for revision and for making up gridded mosaics such as were used for the attack on Bardia. They were unsuitable for new map compilation. In Syria No. 2 Photo Reconnaissance Unit (P.R.U.), a bomber squadron based in Palestine, produced some photography over parts of Syria which was used for revision purposes.

The next period, from July, 1941 to December, 1941 included the completion of hostilities in Syria, the strengthening of British forces in the Middle East, and the build-up of German formations in Libya. In November, the second British offensive into Libya was launched, Benghazi being reoccupied at the end of December. During August, British and Indian forces had entered Persia.

Of chief importance during this phase was the arrival of No. 60 Squadron S.A.A.F. from East Africa in July, 1941. An R.A.F. Flight (No. 1434) was formed in conjunction with 60 Squadron and one aircraft and crew moved over to Palestine to photograph selected defence areas in Syria where large scale maps were needed. This was the first action taken in the Middle East to provide a unit whose principal task was air survey photography, and 60 Squadron S.A.A.F., together with 1434 Flight R.A.F. continued to give invaluable assistance to Survey during the rest of the campaign in spite of the limited and inadequate resources at their disposal. The South African units operated in Egypt and the Western Desert, and 1434 Flight alternated between Palestine, Syria, Iraq and Persia. There were periodical attempts, during the campaign, to take 60 Squadron off survey photographic tasks and switch it over to general reconnaissance duties.

Besides the survey photos provided by 60 Squadron, use was also made of verticals and obliques taken by Hurricanes on reconnaissance sorties. Large areas in Syria were thus dealt with, and in the absence of survey photographs, 1/50,000 sheets on the Cyrenaican frontier area were revised and amplified from rectified obliques.

Between July and October, 1434 Flight photographed over 8,000 square miles in Palestine, Syria, Trans-Jordan and Egypt. 60 Squadron was not ready for operations till the end of August and did not move out to the Western Desert until early October, the delay being due to unserviceable aircraft. Among its first tasks was the photography of 600 square miles in the Gialo area, and a 90-mile strip from Sidi Omar to Bir Hakeim. Enemy opposition was strong, the weather was bad, and the camera shutters started to freeze at over 25,000 ft. altitude. Block flying was not allowed as the aircraft had not a sufficiently good performance in the face of enemy opposition.

During November, 1941, 60 Squadron had an average of only two aircraft available for operational photography in the Western Desert, but it completed over 400 miles of strip flying, and covered 4,500 square miles in Libya. The Western Desert strips were plotted as strip maps or mosaics which were annotated for topographical and military detail. 1434 Flight, after completing its task along the Syrian-Turkish frontier during November, moved over to Mosul for work in Iraq. From the Syrian photos the South African Survey Company

plotted 1/25,000 and 1/50,000 maps of northern Syria, and they also produced a 1/50,000 sheet covering the Maan-Aqaba road in Palestine.

Weather during December, both in the Western Desert and Iraq, was bad, and only on about nine days was it possible for survey flying in the former area. No survey aircraft were available in Ninth Army area in Palestine during December.

While Eighth Army was at the extreme limit of its advance in the Agheila area a big programme of survey photography was required to provide new maps and improve the existing ones of that area. 60 Squadron had only one serviceable camera at the beginning of January, but this situation was remedied and over 8,000 square miles were photographed, after which photo coverage of the Agedabia district was started. Every effort was made to keep two aircraft in the air each day, and the work of the squadron during this period was exceptionally valuable. Meanwhile, during January and February, 1434 Flight continued its activities in Iraq and Persia and by the end of February had photographed a total of over 13,000 square miles. A further 1,600 square miles were covered during March.

In March, 1942, the weather in the Western Desert was very bad, with low cloud and dust storms; the aircraft were near the end of their serviceable life, and no replacements were available. On each of the rare fine days only one aircraft could be put in the air. However, about 30 sorties were flown during the month for use in connection with 1/250,000 mapping in the locality of Benghazi. Control was provided by astronomical observations and points fixed by car and compass traverses.

60 Squadron was refitted during April with reconditioned aircraft and engines, and became fully operational. A limited number of control strips were flown for 1/250,000 mapping in the Agheila and Agedabia areas where some parts of the desert were so featureless that plotting was very difficult. Work was also begun on some new 1/100,000 sheets from photos supplied by 60 Squadron and Photo Reconnaissance units. New F-8 cameras were supplied to the Survey Flights in May, and during the month 60 Squadron beat its previous record by covering 10,000 square miles.

July and August, 1942, were busy months. An area measuring about 140 by 30 miles was photographed south of Wadi Matruh and El Maghra to fill in a gap in the southern parts of the 1/250,000 sheets, Daba and Alexandria, and one flight moved to Beirut to photograph the coastal areas of Cyprus and the Levant. 1434 Flight moved to Tehran and began work in Persia, 3,000 square miles being photographed for the survey of defence positions in the mountain passes and the preparation of 1/25,000 maps.

In September, the aircraft situation with 60 Squadron again deteriorated and little work was possible, only one machine being serviceable. The Director of Survey represented to the Chief of Staff and to the Air Staff the serious situation arising from the shortage of machines, especially at such a critical time when preparations for the El Alamein offensive were reaching a climax. Survey was working at top pressure preparing maps of all sorts, enemy defence over-prints, artillery block-plots, and the survey fixation of enemy battery positions. In this latter connection the positions of new targets after being located on daily reconnaissance photos, were transferred to survey photos, and their positions determined on the block plots. Owing to the lack of sufficient aircraft to do the survey part of the work well in advance, the survey photo cover had to be obtained during the last few difficult weeks in face of heavy enemy opposition.

It cannot be sufficiently stressed how great is the importance of obtaining good quality vertical air-photo cover of possible combat areas before the requirement becomes pressingly urgent, and while the enemy opposition is either non-existent or, at any rate, not intense. It enables counter-battery methods to be put into operation more or less at a moment's notice, and it has, besides, a wider application for topographical mapping, intelligence purposes, and camouflage projects.

The period from October, 1942 to May, 1943 included the El Alamein battle, the pursuit through Libya into Tunisia, and the final phase culminating in the expulsion of all enemy forces from Africa.

Though only one aircraft was available with 60 Squadron during the greater part of October, the situation improved at the end of the month when three Marylands and two short-range Baltimores were allocated. Progress was made in the photography of an area south of the Qattara Depression. 1434 Flight which, during July, August and early September, had covered 3,000 square miles in Persia, was handicapped during October by a serious shortage of suitable and serviceable aircraft. The weather deteriorated rapidly in Persia during October and November, and the Flight was ordered to return to Syria.

60 Squadron was given four new long-range Baltimores in November which added greatly to its operational value over the battle area. With the rapid advance of Eighth Army new programmes were undertaken further and further to the west and in January, 1943, two Mosquitoes became available and were allotted to the squadron, whose work was now recognized as being of such tactical importance to the progress of operations. The first task was to complete the photography of the Mareth defences for large scale map production, and the value of these high-performance aircraft for this class of work became very clear.

During the early part of 1943, photography was undertaken by 2 P.R.U. for the mapping of Rhodes and other islands in the Eastern Mediterranean. 1434 Flight returned to Ninth Army in Syria during January, and started on a big programme extending over 10,000 square miles. As it was equipped with old and almost worn out Blenheims, 1434 Flight could only be used for photography over non-operational areas.

In March, 1943, the Survey Flights were issued with Fairchild K-17 cameras, with 6-inch and 12-inch lenses similar to those being used in Europe for the photography of northern France. Pressure of work in Tunisia during March was very great and the two Mosquitoes could not keep pace with the demand. Amongst other items a block of over 1,000 square miles was photographed in the Gabes area.

April and May saw the closing stages of the operations in Africa. 60 Squadron covered the Pont du Fahs and Enfidaville areas and also the Bon peninsula, but progress was slow owing to bad weather and lack of sufficient aircraft.

From June, 1943, onwards 60 Squadron operated under A.F.H.Q. control in connection with the Sicily and Italian campaigns. 1434 Flight, which was unable to take on tasks outside non-operational areas owing to its unsuitable aircraft, was disbanded in June. Photo squadrons of the U.S. Army Air Force were now arriving in the Middle East, and they undertook various tasks including the photography of coastal areas and localities in the Persian Gulf, the results being used for the revision of the quarter-inch maps. There

was also photography over Greece, Crete, and other Mediterranean areas with K-17 6-inch cameras and this was used for Multiplex compilation of new maps on 1/50,000 and 1/100,000 scale. There was also a project for covering the northern parts of Palestine at 1/15,000 scale for the production of mosaics and enlargements at 1/5,000 of selected towns and villages.

The lessons to be learnt regarding air survey photography during the Middle East campaigns were, generally speaking, similar to those in other theatres. It is impossible to forecast what the survey conditions and requirements are likely to be for any future war, but it seems safe to predict that, whatever may be available in the way of mapping material for any operational theatre, there will always be a requirement for early and complete survey photography for revision purposes and for new map compilation. The dangers and difficulties which may result from a lack of sound policy on the subject and inadequate resources will be obvious from the above brief summary.

#### SECTION 4. TRIANGULATION AND FIELD SURVEYS

##### Early Investigations

In anticipation of possible operations in Egypt, Palestine and Syria the War Office had no cause to be unduly anxious regarding triangulation data. In the two former countries British military forces were already in occupation before the war started in accordance with treaty rights and mandate responsibilities respectively, and there was a close liaison with the local survey departments. France, being the mandatory Power for Syria, controlled the local survey organization, and held much in the way of records and data which would be placed at our disposal.

Little useful information was available before the war regarding Italian triangulation work in their African Colonies, and this lack of data was to remain unsatisfied until documents were captured during the first British advance into Libya in 1940.

Little knowledge was available with regard to survey data in Turkey until the Middle East Survey Directorate made contact with the Turkish Survey Department in 1940.

With regard to the Balkans, the geodetic information held by the Geographical Section General Staff at the War Office before the war was sketchy and incomplete. When, therefore, the B.E.F. was in France during 1939-40, advantage was taken of the fact that the G.H.Q. Survey Directorate was in close touch with the French Service Géographique de l'Armée (S.G.A.). Colonel Hotine, then serving with the G.H.Q. Directorate, visited Paris in December, 1939 and, after discussions with the French geodetic experts, and a study of the available records, he prepared a summary of the triangulation situation in the Balkans, and made certain recommendations regarding future policy in connection therewith.

Subsequently, early in 1940, when Colonel R. L. Brown had been appointed Director of Survey for the Middle East, he and Captain E. H. Thompson visited Paris for a more detailed consultation with the Service Géographique, and to draw up an agreement concerning the preparation and ultimate use of survey data for the Balkans and other areas in the Middle East in which the French had a special interest and for which they held important records.

### Military factors affecting triangulation systems within a war theatre

An important principle of surveying is to avoid local discontinuities. This is achieved in any given area by the laying down of a "primary" triangulation of high precision, which should be adjusted within itself before the less precise "secondary" and lower class work is based on it. Unfortunately, this counsel of perfection is not always followed by national survey departments, and the resultant discordances are a source of much inconvenience.

In modern war the need for consistency in a survey framework is of considerable importance now that survey plays such an important role in connection with artillery action, radar chains, etc. An error of a few metres in the *absolute* position of a point is not of great importance, provided that other points in the vicinity have comparable errors. It is the *relative* accuracy of position between neighbouring points that matters. Positions of points provided by the Survey Service for artillery use should have a relative accuracy which will enable bearings to be calculated from them to within about two minutes of arc. Assuming that points will not be used which are closer together than about one kilometre, this requires a relative accuracy in position of about 0.5 metre.

In any well conducted modern national survey, it should not be difficult to achieve this standard but, in many areas over which operations were conducted during the war a confusion between old and new survey systems, faulty methods of adjustment, and errors of printing and typescript in the preparation of trig lists, produced relative errors of displacement which exceeded this allowable toleration.

Discrepancies are often found along the junctions between national triangulation systems in frontier areas. Each system is probably based on its own origin for absolute position, its own base measurement which affects the scale, and its own determined azimuth or bearing along the basic side or sides of the triangulation. Very often also the so-called "common points" between two systems are not strictly common. It sometimes happens that both countries select the same hill-top on one side or other of the frontier on which to establish a triangulation station and, for some reason or other, do not both use the same identical point. The two points may be some metres apart. In the trig data of the two countries these points, although they bear the same name, will carry values which are not sympathetic.

Operations frequently take place on or across an international frontier, and it is not wise to accept the independent triangulation values of adjacent countries in the hope that they will be sufficiently in agreement to enable them to be used without further ado. Relative discrepancies of as little as five to ten metres will cause large angular errors between points lying close together but belonging to different national surveys, and these points may fall within a battle area and be required for use by the artillery in connection with fire control and predicted shooting.

It was for this reason, therefore, that it was necessary to decide what action should be taken with regard to the numerous separate survey systems which existed in the Balkans, where Austrian survey influence had been strong. As a result of the discussions in Paris, it was agreed to reduce all the various primary triangulations to one homogeneous system which would be known as the Balkan Homogeneous System, and as, at that time, more triangulation data was possessed for Austria than for any of the Balkan countries, the new homogeneous system was to be based on, and adjusted to, the Austrian triangulation. The computations for this work were to be carried out by the

French Service Géographique. As will be seen subsequently, pressure of events early in 1941 at the time of the Greek crisis and the acquisition of much new Greek data made it undesirable and uneconomical to adjust the Greek triangulation to this proposed Balkan system and, as a consequence, most of the Balkan area was eventually assimilated to the Greek triangulation instead of into the old Austro-Hungarian network as had originally been proposed.

While considering the action that was initially proposed it may be well to summarize briefly the various national triangulations that were at that time known to be in existence in the Balkan area. The work that was undertaken will then be more clearly appreciated. Triangulation problems affecting the remainder of the Middle East Theatre will be dealt with in later paragraphs.

### Triangulation systems in the Balkans

- (a) *Austria, Hungary.* The largest single self-consistent block of triangulation was that of the old Austro-Hungarian Empire. There were several points of this system in northern Yugoslavia, and a coastal chain ran down the Adriatic shore as far as the Greek border. It was originally intended to use this triangulation as the basic network to which all the others would be adjusted. As it had been computed on the Bessel spheroid, it was decided to adopt "Bessel" for all the Balkan computations.
- (b) *Yugoslavia.* The available data initially consisted of the adjusted angles and logarithmic sides of a meridian chain having common points with the Austrian system in the north and the Greek triangulation in the south.

In the north there was a difference in scale of one part in 20,000 in the lengths of common sides between Yugoslav and Austrian systems. About 50 miles to the south of this junction, however, there was a Yugoslav measured base, and the length of the primary side computed from this base was held fixed, and the scale difference was smoothed out by a rigorous adjustment between that fixed side and the connection with the Austro-Hungarian system.

Using the Austrian geographical values as starting elements, the co-ordinates of all points in the Yugoslav chain were computed on the Bessel spheroid and, as the original Yugoslav computations had been on the Hayford spheroid, the adjusted angles of the chain had to be modified by the small differences in spheroidal excess between the Hayford and Bessel figures.

- (c) *Greece.* The national triangulation of Greece had been computed on the Bessel spheroid, and was based for origin on a geodetic pillar near the Athens observatory. The published Greek values for latitude and longitude had been based on a value for the Athens origin of:—

Lat.  $37^{\circ} 58' 20\cdot10''$   
Long.  $00^{\circ} 00' 00\cdot00''$

The above latitude value was the result of a determination made in 1889 and, though a more recent astronomical determination in 1927 gave a new value of  $37^{\circ} 58' 18\cdot68''$ , this latter had not been used in any computations affecting either the triangulation or mapping of the country.

In 1927 also, a provisional longitude of the Athens Pillar referred to above had been published. This gave a value of  $23^{\circ} 42' 58\cdot5''$  (E.)

from Greenwich, and it was adopted, by British and French agreement, as the fundamental longitude of the new proposed Balkan system.

The Greek triangulation itself dated from four periods, the first dating back to 1889, and the fourth being work carried out subsequent to 1930, which included the connection with the Bulgarian system and a few triangles in the Aegean and Ionian archipelagos. Amongst the Greek work was an arc of meridian which extended the Yugoslav meridian chain southwards to Crete.

At the time when the computations were being done for the Yugoslav meridian chain referred to above, the modern observed angles of the Greek chain were not available. The Adriatic triangulation in Greece connecting Athens with the Austrian coastal chain did not appear to be of first quality, and it was therefore decided to fix the position of Athens in the Austrian system by the method described below.

A point on the Adriatic coast (Pandokrator) was known to be common with the Austrian coastal chain, and another point (Kaimak Calan) was known to be common with the Yugoslav chain. Together with the Athens Pillar these points formed a well-conditioned triangle whose angles could be computed from the published Greek geographical co-ordinates. The azimuth and length of the side Pandokrator-Kaimak Calan were obtained from the Austrian co-ordinates, and from these values the following co-ordinates were calculated for the Athens Pillar:—

Lat.  $37^{\circ} 58' 20\cdot441''$   
Long.  $41^{\circ} 23' 11\cdot290''$  E. of Ferro.

As stated previously it had been agreed that the value  $23^{\circ} 42' 58\cdot5''$  (E. of Greenwich) would be adopted for the longitude of the Athens Pillar and that all longitudes would be modified by an amount necessary to give Athens that value. The difference of  $17^{\circ} 40' 12\cdot790''$  was therefore subtracted from all Austrian values to convert from Ferro to Greenwich.

It will also be remembered that a recent astronomical determination for the latitude of the Athens Pillar gave a value of  $37^{\circ} 58' 18\cdot68''$ . The difference between this and the value deduced from the Austrian system *viz.*  $1\cdot761''$  represented a linear displacement of 56 metres. It had been agreed that, should this difference be less than 50 metres, the Austrian value would be accepted for Athens but that, should it be greater, the new astronomical value would be adopted and the Austrian values adjusted accordingly. As the difference did exceed the stipulated 50 metres the latter course was followed. Correction graphs were then prepared by which the Greek-published geographical co-ordinates could be transformed to the homogeneous Balkan system. The scale of the graphs was selected so that the distance between two lines representing  $0\cdot1''$  difference in latitude or longitude amounted to about two centimetres on paper. When interpolating, therefore, an interval of approximately 2 mm. was equivalent to the selected limit of  $0\cdot01''$ . The transformation of longitudes consisted first in adding  $23^{\circ} 42' 58\cdot5''$  (the accepted longitude of the Athens Pillar referred to Greenwich) to the published longitudes measured from Athens and then adding a small correction from the graph.

- (d) *Bulgaria.* The Service Géographique in Paris had amongst their records some annual reports on Bulgarian surveys for a few isolated years between 1922 and 1930. These contained actual angular measures executed during the year. The triangulation was a new one, apparently well observed and marked, but the records were incomplete, several years being missing. No geographical co-ordinates were given in these reports. It was learnt, however, that the Bessel spheroid was to have been used for the computations.

In the absence of full data at that early period to enable a connection to be made between Greece and Bulgaria the triangulation of the latter was computed separately as an isolated system. Later, when the necessary data became available, the Bulgarian points were adjusted to the values of the Greek common points in the homogeneous system.

- (e) *Turkey.* As a result of information supplied by the Turkish Survey Department to the Survey Directorate in Middle East in April, 1940, the available knowledge about the Turkish triangulation system was increased, but little useful data were obtained other than the geographical and rectangular co-ordinates and the measured angles of a chain of triangulation in Thrace common with Greece and Bulgaria.

Turkey had computed its triangulation on the Hayford spheroid, and had referred positions of points to an origin at Kandilli, near their observatory, whose value was:—

Lat.  $41^{\circ} 03' 48.899''$

Long.  $29^{\circ} 03' 55.200''$

The projection system used in Turkey was the Gauss-Kruger, indicative of German influence during the First World War.

An investigation was made by the Survey Directorate into the triangulation chain which had been observed by Greek and Turkish observers along their common frontier. The quality of the work appeared to be sound, and the maximum triangular misclosure in the chain was about two seconds. Taking the Turkish values for the co-ordinates of points lying in Turkey based on Kandilli as origin, and the Greek values for points lying in Greece based on the Athens Pillar as origin, the discordance between the two triangulations was determined. There was a considerable scale difference between the two, amounting to about one part in 3,700, the Turkish being the smaller.

In order to allow Turkish maps to be gridded, a provisional value was worked out for the co-ordinates of St. Sophia on the Balkan system. In the absence of triangulation data for Turkey, the formulae obtained from the investigation referred to in the previous paragraph were used, and by extrapolation a fair estimate was reached as to what difference there was between the Turkish and Greek values of St. Sophia. By subtracting these differences from the Turkish values the co-ordinates of St. Sophia on the Greek system were deduced and, by using the correction graphs, a further correction was obtained for transforming these values to the Balkan system.

- (f) *Roumania.* The only special publication concerning the Roumanian triangulation at the Service Géographique in Paris was an article of

general interest which indicated that there were probably three current systems, and that the whole country was not yet covered.

### **Grid Zones in the Balkans (See Diagram 2)**

In any operational theatre it is obvious that the less often the projection and grid change the better. Taking as an axiom that an orthomorphic projection is the most generally suitable for military purposes, where direction and scale over limited areas are required to be as correct as possible, the actual choice of projection will depend largely on the general shape of the area. The Balkan area was as broad as it was long and the Lambert projection, being about the simplest of the orthomorphic family, appeared to be the obvious choice. The Service Géographique were considering an extension of the French Lambert II and III belts across to the Balkans on their existing parallels, and adding a similar Lambert IV belt to the south. One of their main reasons for suggesting this was because there were already in existence projection tables for Lambert II and III. As stated above, however, the Bessel spheroid was the obvious selection for the Balkans, and the French Lambert tables were based on the Clarke 1880 spheroid. In addition the French projection belts were narrow ones and, when starting with a clean slate, it would obviously be better to adopt wider belts which would give less grid changes within the battle area.

It was finally decided to cover the area with two Lambert grid zones, the Danube Zone in the north, and the Mediterranean Zone in the south, the junction between the two passing through the northern tip of Albania, south-eastern Yugoslavia, the middle of Bulgaria and the Black Sea.

The Danube Zone effected a junction on the west with the northern Italy and Nord de Guerre Zones, on the north with the various Russian belts, and on the east with the Caspian and Caucasian Zones.

The Mediterranean Zone had a junction on the west with the southern Italy Zone, on the south with the Libya Zone, and the Egyptian Purple and Red Belts, and on the east and south-east with the Caucasus and Levant Zones and the isolated Cyprus grid. The isolated Crete grid lay within the southern extremity of the Mediterranean Zone.

### **The final arrangement of triangulation in the Balkans**

- (a) *The Greek System.* The original intention, as has been stated previously, was to compute all triangulation data on one homogeneous Balkan system based on the Austro-Hungarian triangulation. Until about November, 1940, there were more data available for Austria and Hungary than for any of the Balkan countries but, after the entry of Greece into the war against Italy, a very large amount of new Greek trig data were made available to G.H.Q. Middle East by the Greek General Staff and Survey Department, who proved most co-operative. These new data comprised values for all the Greek minor triangulation numbering some thousands of points, all of which were in sympathy with the Greek large scale maps which were also made available for the first time. The task of preparing trig lists, including the translation of descriptions of points into English, was a formidable one in itself and if the extra task of converting all these new points to the Balkan Homogeneous System had been attempted, it was clear that it could not have



been finished within a reasonable time. D. Survey, Middle East therefore decided to make a change of policy, accept the Greek system as the basic network, and to base on it all the other Balkan triangulations which, at that time, were of less importance.

This new homogeneous system had as its neighbours:—

- (i) The Italian geodetic triangulation.
- (ii) The French system, which was based on the old French triangulation.

(b) *Adjustment between triangulation datums.*

In each of the Greek, Italian and French Zones, all the triangulation work within each zone was adjusted to its own zone datum. From an investigation into discrepancies between the geographical co-ordinates of common points, a table of differences was obtained for use in the adjustment between triangulation data as under:—

	<i>Lat.</i>	<i>Long.</i>
Greek minus Italian	+ 1·549"	— 10·863"
Greek minus French	— 1·262"	— 18·921"
Italian minus French	— 2·811"	— 8·058"

(c) *Trig lists.* These were compiled by the Survey Directorate, Middle East, wherever possible based on sheets of the 1/100,000 series.

Where grid systems met, an overlap of at least 30' was provided, and trig lists gave co-ordinates on each of the adjoining grids.

Where triangulation datum areas joined, an overlap of at least 30' was provided and trig lists gave co-ordinates on each of the adjoining datums.

(d) *Adjustment and computation.*

Having decided to use the Greek system as the basic network, the triangulations lying to the north of it had to be adjusted to the Greek datum.

As time was limited, and in order to avoid the complication of readjusting the northern triangulations into terms of the Greek orientation, they were assimilated to the Greek datum by applying a constant correction derived from a comparison of values at three common points in the area of Boscop. These triangulations were then used as the basic network in the Balkans, and all other systems were brought into sympathy with it.

(e) *Use of contour graphs for triangulation adjustment.*

The adjustments, which were made graphically by means of correction graphs, dealt with:—

- (i) Change of spheroid.
- (ii) Scale differences.
- (iii) Errors in orientation and position due to the effect of deflection of the vertical at the point of origin of the survey.

Graphs were of two kinds:—

- (i) Those which gave corrections to rectangular co-ordinates.
- (ii) Those which gave corrections to geographical co-ordinates.

Although both types of graphs were used in the adjustment of the Balkans systems, it was generally considered preferable to adjust in terms of geographicals.

When triangulations were homogeneous, then a regular conformal correction graph could be drawn, based on differences at common points.

It was often found difficult to identify points which were, in fact, identical to two surveys, particularly when there were large differences in scale and orientation. Also when surveys had been made at different times, the old station mark had often disappeared and a new one established, possibly a metre or two away.

Trig data were sometimes received in the form of a list of geographical co-ordinates without any explanatory notes as to its origin. It was necessary to ensure that the values were homogeneous, and that the lists had not been compiled from different sets of original records which were not in sympathy with each other. This occurred in the case of the data received for the Serbian first order triangulation. It was found, fortunately, that discontinuities of this nature became obvious when the graphs were being drawn.

### **The Western Desert and Cyrenaica**

The attitude of Italy as an Axis partner indicated that the Western Desert of Egypt and Cyrenaica were likely to become operational areas. When, therefore, G.H.Q. Middle East was formed early in 1940, these areas were treated with priority urgency with regard to mapping and triangulation data.

For the Western Desert the results of triangulation work carried out by the Survey of Egypt were available. For Cyrenaica there was very little known, before the first British offensive in December, 1940, regarding any Italian survey work which might have been completed.

For military purposes the triangulation and maps of Egypt, the Western Desert, and Cyrenaica were referred to three different grids, the Red and Purple Grids in Egypt, and one covering the whole of Libya known as the Libya Grid. (See Diagram 2.)

The Egyptian grids were based on the Transverse Mercator projection using the Helmert spheroid. The Red Belt extended eastwards from Long. 29° (about 50 miles west of Alexandria) to the middle of the Sinai peninsula where it met the Palestine Transverse Mercator Grid. The Purple Belt extended westwards from Long. 29° to its junction with the Libya Grid, about 100 miles west of the frontier between Egypt and Cyrenaica.

The Libya Grid was based on the Lambert Conical Orthomorphic projection, using the Clarke 1880 spheroid. It extended westwards to its junction with the North West Africa Grid at Long. 11° E. in the neighbourhood of the Tunisian frontier.

The Western Desert was considered as being that part of Egypt which lay between the cultivated area of the Nile Delta and the frontier at Sollum. As part of the Egyptian triangulation network there was a geodetic chain which extended along the coast from the Libyan frontier in the west as far as El Alamein, and then south-east to Cairo and along the Nile Valley. There was another chain running eastwards from Cairo to Suez. A second-order triangulation, adjusted to the geodetic chain, covered the whole of the cultivated area, and a third- and fourth-order triangulation had been completed and adjusted to the second order network. The Egyptian Survey Department maintained these triangulations up to date, and replaced any trig stations that might be destroyed or damaged.

The whole of the Western Desert area, from the coast as far south as about Lat.  $28^{\circ} 31'$  was covered by a network of "desert points" which were controlled, on the north side only, by the geodetic and second-order triangulations. As a consequence the work had to be adjusted at various points to observed azimuths and chained base lines. Most of the sides of this desert network were short, about 10 kilometres in length, and although it could not be considered to be of first-class quality, it was adequate for mapping purposes and artillery use.

The geodetic and second order triangulations had been computed and adjusted using geographical co-ordinates on the Helmert spheroid, and their rectangular co-ordinates were obtained by second difference interpolation from the co-ordinates of a graticule which was computed for every  $2' 24''$  in latitude and  $3'$  in longitude.

The third- and fourth-order triangulations were computed on the plane and adjusted to fit the rectangular co-ordinates of the higher order points.

The co-ordinates of all trig stations in the Western Desert were compiled in trig lists conforming to the sheet lines of the Survey of Egypt 1/100,000 map series.

Descriptions of stations and trig diagrams were not available, but nearly all the points had been plotted on the 1/100,000 maps, which made their identification possible. As a rule, the geodetic stations were marked by an iron cylinder filled with concrete, and the desert points by iron posts covered by stone cairns.

As previously stated very little, if any, triangulation data were available for Cyrenaica before the war. It was, however, noticed that the incidence of topographical detail on Italian 1/100,000 maps in the neighbourhood of Sollum was not in sympathy with that on the corresponding Egyptian maps. For the purpose of gridding these maps it was essential, therefore, to determine a provisional correction to the printed Italian graticule in order to avoid an undesirable "cassure" in the frontier area. Unfortunately a firm triangulation connection had never been made before the war between the Egyptian and Italian triangulations in the frontier area.

While the Mobile Echelon of 512 (Army) Field Survey Company R.E. was working in the frontier area during 1940, opportunity was taken to carry out intersection observations on to the Italian Fort Capuzzo by forward rays from Egyptian triangulation stations. The Fort could be identified on air photographs and on the relevant sheet of an Italian 1/50,000 map of the area. The geographical co-ordinates were scaled from the map, converted to Egyptian Purple Grid co-ordinates, and compared with the values obtained from the field observations. The resulting difference in rectangular co-ordinates was then converted to a difference in latitude and longitude which gave a provisional correction to be applied to the Italian geographicals to bring them into line with the Egyptian system. This correction was:—

For latitude —  $7.7''$ .

For longitude —  $13.6''$ .

As a check only, a comparison was made between numerous points of detail which were common to the Egyptian and Italian maps, and these agreed so closely with the result obtained from the Fort Capuzzo observations that the latter was accepted as giving the provisional correction to be adopted. The Italian maps were therefore gridded, first of all by amending the Italian graticule by the above correction, and then converting the amended values to Purple Grid co-ordinates.

During the early days of the British offensive, Italian lists giving geographical co-ordinates of numerous triangulation stations were captured and these were hurriedly transformed to the Libya grid. The corresponding rectangular co-ordinates were derived by means of tables based on the Clarke 1880 spheroid, without any consideration being given to a possible difference in spheroid between that used for the British Libya grid tables (Clarke 1880) and the spheroid which might have formed the basis of computation of the Italian geographicals. The Italian spheroid of reference was, at that time, not definitely known, but several computations of "point to point" working on the Bessel figure had agreed very closely with the geographical co-ordinates, and it seemed safe to presume that the Bessel figure had been used. This was subsequently confirmed by a later captured document.

This mix-up of spheroids when transforming co-ordinates, resulted in a distortion of the triangulation and a considerable departure from the orthomorphism of the projection, not sufficiently great to be of much consequence for artillery use, but appreciable enough to affect any large extension which might be made from the existing network.

At a later stage in the offensive further lists giving geographical values were captured, and it was noticed that they were not in sympathy with the Italian co-ordinates from which previous lists had been prepared. It seemed evident that there were two distinct triangulation systems in Libya, and these were thereafter known as the Eastern and Western systems respectively. There appeared to be one common point only between these two. Examination of the 1/100,000 sheets showed also that the Italian 1/100,000 map series was not a homogeneous one, but was based on two independent triangulations which were not in sympathy. It was also apparent that the Italian 1/50,000 series covering the area from Derna to Benghazi was based on an early triangulation dating back to 1920, whereas the 1/100,000 maps of the same area were based on a more recent survey, and the geographical positions of map detail did not agree between the two series. Unfortunately these facts were not known when the maps had been first gridded by the Survey Directorate.

This confusion of basic control data made it impossible to correct the geographical co-ordinates in such a way that:—

- (a) the points would plot correctly on the Italian 1/50,000 and 1/100,000 Western sheets both from geographical and rectangular co-ordinates, and
- (b) the co-ordinates of the common point would agree in both systems.

In order to preserve the correct plotting of the points, it was thought best to keep the two systems independent. The procedure outlined below was therefore adopted.

The geographical co-ordinates of all points in the Western system were corrected first of all by an amount which the Italians had themselves applied to allow for the shift of graticule. A further correction was then applied to bring the points into sympathy with the Survey of Egypt.

This correction to the Western system values was:—

*Latitudes.*

Italian correction	+ 8·31"
Correction to bring into sympathy with Egypt	— 7·70"
	+ 0·61"
Total	+ 0·61"

*Longitudes.*

Italian correction	+ 1' 12.45"
Correction to bring into sympathy with Egypt	- 0' 13.60"
	<hr/>
Total	+ 0' 58.85"
	<hr/>

The alternative procedure of correcting the Western system to agree with the Eastern was considered to be risky, since there was only the one known common point, and even if the values of this point were good, nothing was known about differences of scale and azimuth. The two systems were therefore kept separate and when field parties wanted to base new work on trig list values, they had to be very careful to use starting elements which were taken from either one system or the other, but never from a mixture of both.

When the Allied advance reached Benghazi, the Mobile Echelon of 512 Field Survey Company was able to carry out field observations in order to tie the Eastern and Western systems rigidly together. The adjustment was then effected by means of a contour correction graph, similar to those used for the Balkan adjustments and elsewhere. New trig lists were compiled for the newly adjusted co-ordinates. The result of this alteration of co-ordinates was that the existing gridded maps were no longer in sympathy with the new trig lists, and they therefore had to be redrawn and regrided. Attention has already been drawn to the break in continuity between the Egyptian and Italian triangulation systems at the frontier near Sollum, and to the provisional correction which was applied so as to bring the Italian Eastern system into closer agreement with the Egyptian network. This correction, it will be remembered, was obtained by scaling from a map in conjunction with intersection observations to Fort Capuzzo. At the first opportunity after crossing the frontier the Mobile Echelon of 512 Company effected junction between the two by means of field observations. The result was that the Italian values were found to be out of sympathy with the Egyptian values by an amount which was too great to be smoothed out. Since the Egyptian triangulation could not be altered, and it had been decided to keep the Italian Eastern system fixed, it was necessary to prepare duplicate trig lists for an overlap area between the two systems giving co-ordinate values in both systems.

It will be appreciated from the above that the different stages and processes of adjustment to which the Cyrenaican triangulation had to be subjected were considerably involved. For clarity, the main steps have been arranged in the form of a diagram (*see* Diagram 3) which it is hoped will make the situation easier to follow.

### Syria and the Levant

*Primary triangulation.* The primary triangulation was the product of the following bodies:—

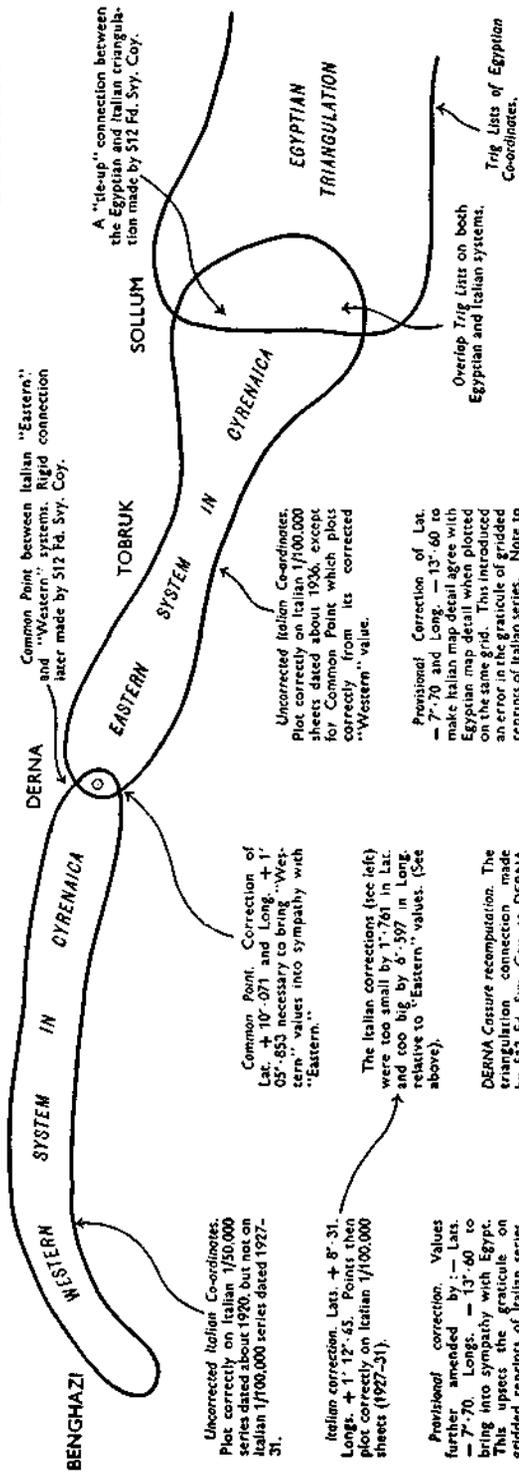
The Service Géographique de l'Armée Française (S.G.A.).

The Iraq Petroleum Company (I.P.C.), also known as the Syrian Petroleum Company (S.P.C.).

The Bureau de Cadastre (B.C.).

In addition, minor triangulation had been carried out by the Bureau Topographique des Troupes du Levant (B.T.).

DIAGRAM 3



Maps Italian 1/100,000 and 1/50,000 series redrawn and re-gridded to be in agreement with Final Trig Lists.

Final Trig Lists produced which superseded previous ones.

**Adjustments to the Triangulation Systems in Cyrenaica**

Trig Lists, produced containing Italian values converted to Libya grid after correction as above.

The S.G.A. triangulation was the work of officers sent to Syria from Paris, and there was apparently little co-operation between them and the B.T., which was a local military organization under the command of the G.O.C. Levant. In a report published by the S.G.A., called the "Memorial du Service Géographique de L'Armée," the triangulation carried out by the S.G.A. between 1920 and 1929 was described, but few details of the work were available, only the results.

The Bureau de Cadastre was responsible for land registration, and all records of their work were available in their offices in Beirut.

The work of I.P.C. had been carried out in connection with geological prospecting and the delimitation of concessions. Their records were available in the offices of the company at Haifa, and also with the B.T. in Beirut.

The principal triangulations in Syria are described briefly below:—

#### SERIES A. ALEPPO MERIDIAN CHAIN AND THE COASTAL SERIES.

The division of this primary series into two parts was purely arbitrary, all the work being of the same high standard of accuracy. The Aleppo Chain was the backbone of the triangulation, the observations for which had been carried out by the S.G.A. between 1920 and 1929. The origin of the system for azimuth and latitude was the south terminal of a measured base at Bekaa. The fundamental longitude had been measured at the geodetic pillar at Ksara, and it was transferred through the triangulation to the origin at the Bekaa base terminal. A second base had been measured at Bab, and the scale of the triangulation was governed by the two bases. A check azimuth, latitude and longitude were measured at the Bab base. The triangulation was computed on the Clarke 1880 spheroid.

#### SERIES B. THE DJERABLOUS-MENNBIDGI SERIES.

This was observed by the S.G.A. with the same precision as the Aleppo chain, to which it was rigorously attached at four points. Starting elements of this series were used for the second-order Euphrates Valley Series.

#### SERIES C. THE EUPHRATES AND TURKISH FRONTIER PRIMARY SERIES.

This was observed between 1934 and 1937, and must not be confused with the second-order Euphrates Valley series mentioned above, with which it was not wholly in sympathy.

#### SERIES D. THE HASSETCHÉ SERIES.

Observed by the S.G.A. between 1932 and 1933. Provisional values of the co-ordinates were issued, based on astronomical values of the south base terminal of the Hassetché Base. These provisional values were used for a considerable amount of the B.T. minor work, and for all the original I.P.C. work in the area. But the co-ordinates of all primary points published in the G.H.Q. trig lists were based on the Bekaa system, though some of the minor points still remained based on the Hassetché system. This led to some confusion in the field. The Hassetché system was eventually connected to the Aleppo Chain through triangulation series B and C above and was re-computed, holding the Hassetché base fixed, but ignoring the astronomical observations at the Hassetché base terminal.

#### SERIES E. I.P.C.'S FRONTIER POINTS.

There was a gap along the Turkish frontier between series B and C which was filled by three points of the I.P.C. triangulation. The work was not in the geodetic class, but was up to good secondary classification.

#### SERIES F. CADASTRAL CENTRAL SERIES.

All the Cadastral primary work was of the highest standard, and it was on this work that series G (below) was based. The series was on the Bekaa system, and well tied to the surrounding S.G.A. work.

#### SERIES G. I.P.C. CENTRAL SERIES.

This, as in the case of series E, was a ruling triangulation with good second-order accuracy. It was tied into the Cadastral points of series F, and also along its northern boundary to series C. All points were on the Bekaa system.

#### SERIES H. ABOU KEMAL CADASTRAL SERIES.

This started from two stations of series C, and was a well-observed work. Though, for a primary triangulation, the sides were short, and it was without a check base, it was reliable.

*Minor triangulation.* Broadly speaking, all minor work to the west of Long. 40° E. was based on the Bekaa system, that to the east being on the Hassetché system.

The work as a whole can be divided into four main groups, each group consisting of a number of observation blocks. The points published in the G.H.Q. trig lists followed the French arrangement of compilation by sheets of the French 1/200,000 map series. In addition to the published points there were a great many minor cadastral points with a 1-km. density in the cultivated areas. Field surveyors had to be very careful in the identification of these points, applying check rays to make sure that they were using the correct one.

#### GROUP 1. THE EUPHRATES AND IRAQ-SYRIAN FRONTIER.

*Blocks Nos. 30-34. Euphrates Valley.* This was the work of the B.T. It was probably the only first-class work in this group, and it was based on the provisional values of Primary Series B.

*Block No. 35.* A rapid triangulation carried out for the Syria-Iraq Boundary Delimitation. It was of third-order accuracy only. Though attached to Block 34 (Euphrates Valley), it was not in sympathy with it, owing to the acceptance of an astronomical azimuth and a weak connection.

*Block No. 36.* Probably the weakest of the frontier series, and it was not quite clear how it was attached to the surrounding work, though there was evidence to show that it might have been attached to one side of Block 35.

*Block No. 38.* Another rapid triangulation, but reasonably good. It was tied into Primary Series C, but could not be said to be either on the Hassetché or the Bekaa system, as provisional field values in the former system were used as starting elements. The values were later converted to Bekaa terms, in view of the good connection with the primary points.

*Block No. 49.* Carried out by British surveys on the Iraq Boundary Commission. No points from it were included in the French lists from which the G.H.Q. lists were compiled. It overlapped Block 38 (above) and had one side in common with Block 36. Its starting elements were sides of the Iraq tertiary series which was not, at the time, attached to the Iraqi secondary work.

## GROUP 2. THE HASSETCHÉ GROUP.

- Block No. 40.* *Turkish Frontier Boundary Commission.* The points belonging to this block were not included in the trig lists. It had its own starting elements, and though the names of some of its points were the same as those in Block 41, they were not common points.
- Block No. 41.* *Region Haute Jezireh, 1936.* A well-observed triangulation, properly attached to the primary network. Co-ordinates were in the Hassetché system.
- Block No. 42.* *Region Hassetché, 1937.* A good triangulation which was in sympathy with the Hassetché Primary.
- Block No. 43.* *Abdul El Aziz Sud, 1938.* Similar to No. 42.
- Block No. 47.* *I.P.C. Haute Jezireh, 1934.* Good work on the Hassetché system. It was re-computed on the Bekaa system.
- Block No. 48.* *Region El Rhana, 1938.*  
*Region Cheikh Mansour, 1937.*  
This was I.P.C. work based on Hassetché co-ordinates.
- Block No. 51.* *Bornes de Permis de Recherche de Pétrole de la Société des Pétroles et Asphaltes de Lattaquieh.* Unreliable work which was not used.

## GROUP 3. THE JEBEL DRUSE-JEBEL TENF GROUP.

- Blocks No. 21 (BT 1939), No. 22 (BT 1937) and No. 23 (BT 1937).* Observed by the Bureau Topographique and not very reliable. Supposed to be attached to the primary triangulation in Bekaa elements and to each other, but the connections were not good. Useful for small scale mapping but not otherwise.
- Block No. 24.* *Triangulation Frontière 1932.* A good British-French boundary triangulation having its own starting elements and attached in the Jebel Druse area to No. 23. Its base was at Jebel Tenf, and the latitude, longitude and azimuth were measured by the British survey party.
- Boundary Triangulation.* *Jebel Tenf-Abou Kemal.*  
A British triangulation which had not been allotted a French serial number. It was attached to Block 34 at Abou Kemal and to the origin at Jebel Tenf (*see* No. 24 above).

## GROUP 4. THE CENTRAL GROUP.

- Block No. 25.* This was I.P.C. work and was computed from the values of points in Series H.
- Block No. 26.* *Bureau Topographique, Saba Biar, 1934.* A reliable triangulation attached to the Cadastral Primary. A few points of No. 24 were intersected from No. 26, but the two blocks were not adjusted together.

## Palestine

Before the war, the ruling triangulation was established and maintained by the Survey of Palestine. Apart from minor extensions in Trans-Jordan, the

triangulation covered the area from the coast to the Jordan River Valley and from the Syrian frontier in the north as far south as Lat.  $31^{\circ}$  N. No permanent triangulation had been established between this parallel and the Egyptian frontier. The extent and general arrangement of the work is shown in Diagram 4.

The Palestine major triangulation consisted of about 100 stations with sides of average length 15 kms. There were approximately 1,100 secondary stations, and 20,000 third- and fourth-order points established within the major framework. The major work was well observed, rigorously computed, and of a high order.

The final results were recorded by the Survey of Palestine in the form of Cassini rectangulars, made up into lists conforming to the sheet lines of the Palestine 1/25,000 map series, which measured 10 kms. square.

As stated above, the Survey of Palestine rectangular co-ordinates were computed on the Cassini projection. As this was not conformable, it was unsuitable for military survey purposes and a Transverse Mercator grid was therefore established to replace Cassini. The origin was a point at Jerusalem with geographical co-ordinates:—

Lat.  $31^{\circ} 44' 02.749''$ .  
Long.  $35^{\circ} 12' 39.290'' + 4.200''$ .

The additional  $4.200''$  to the longitude was in accordance with a 1928 decision to adopt the French value for the longitude of points of junction with the French triangulation in the north, and to correct all Palestine longitudes accordingly.

The true origin of the Cassini projection was retained and also the numerical values of the false origin so as to be able to retain the gazetteer and various maps which had already been prepared. The only amendment to the Survey of Palestine co-ordinates was the application of small corrections to the Cassini eastings in order to correct them to the Transverse Mercator values. The northings were the same for both projections, so no alterations to them were involved.

The limits of the Transverse Mercator Grid Zone were as under:—

*East.*  $39^{\circ}$  E. where it made junction with the Iraq and Muscat Zones.

*West.* The 70-km. easting line (Palestine Grid) where it made junction with the Egyptian Red Grid.

*North.* The junction with the Levant Grid along the 150-km. northing line of the latter.

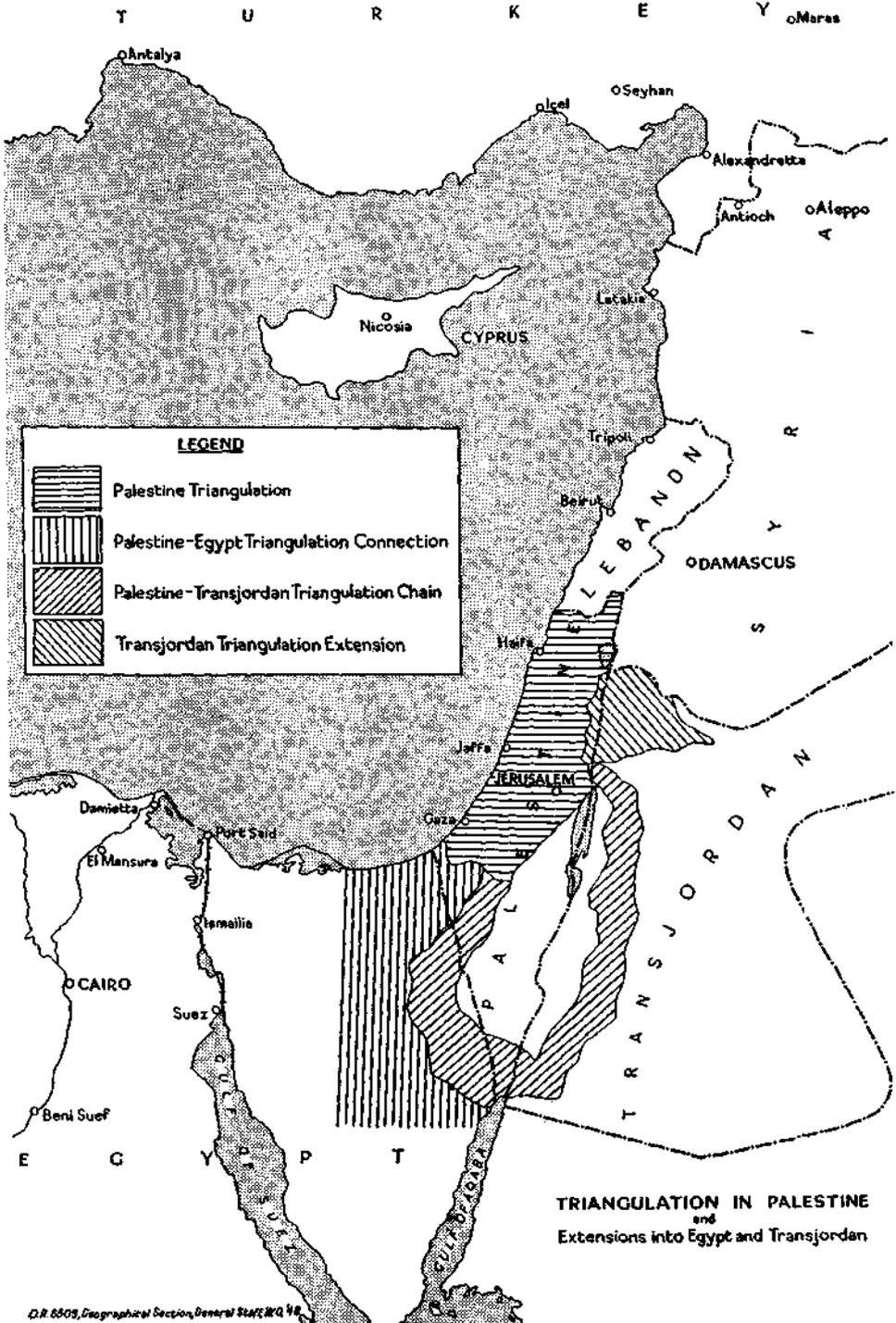
*South.* A Loxodrome passing down the middle of the Red Sea.

The Palestine Transverse Mercator co-ordinates were compiled in lists conforming to the Palestine 1/25,000 map series.

The area covered by the Trans-Jordan triangulation extension is shown in Diagram 4. The work was started some years before the war, but had only been observed and had not been finally adjusted. The original observations and data were obtained by the Survey Directorate, Middle East, and the necessary computations were done by 2/1 Australian Field Survey Company.

During the few years just before the war, a triangulation net had been extended southwards from the Palestine major triangulation to join the Egyptian geodetic chain which ended close to the Palestine border. The observations

DIAGRAM 4



TRIANGULATION IN PALESTINE and Extensions into Egypt and Transjordan

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were unreliable, and a junction had been made at one point only. It was therefore decided by the Survey Directorate to establish another connection and to extend it into Trans-Jordan at the Gulf of Aqaba. This work was undertaken by the South African Survey Company, who re-observed the old connection and established four new stations in order to expand the lengths of the triangulation sides up to those of the Egyptian Geodetic Survey.

At the same time the 36 New Zealand Survey Battery extended the Palestine triangulation down the eastern side of the Dead Sea in order to provide suitable mapping control points along the Palestine-Trans-Jordan border. This was eventually connected to the stations established by the South African Survey Company at the Gulf of Aqaba, and so completed a circuit of triangulation called the Palestine-Trans-Jordan Chain.

The Chain started from stations of the Palestine major network near Beer-sheba and connected up with four stations of the Egyptian geodetic system to the south-east of El Arish. It then ran along the Palestine border to the Gulf of Aqaba, thence passed through Trans-Jordan, and closed on the Palestine major network near Jericho. Where it passed along the Palestine southern boundary it included stations of the Egyptian third-order triangulation wherever possible.

Observations were made on to both luminous and opaque signals, and the results were within the limits of accuracy laid down for second-order work.

Each polygon or quadrilateral within the system was first of all treated separately for angle and side adjustment, then, with the co-ordinates of the Palestine major stations near Beersheba as starting elements, the chain was computed right through to its junction with the Palestine network near Jericho. The closing error was distributed through the chain by the method of contour graph adjustment.

Two bases were measured in Trans-Jordan by catenary method, but as there was difficulty in standardizing the tapes, the bases were used as a check only and did not govern the scale of the work.

Azimuth observations were made to Polaris at three stations. The results were consistent in themselves but differed from the azimuths as computed from the final co-ordinates. Possibly the Rift Valley was responsible for a deflection which would have affected the observed values. The results were used as a check only.

Several subsidiary stations were established in Trans-Jordan, mainly along the Maan-Aqaba road. They were fixed by intersections, resections, or subtense methods from the major stations and were suitably marked. In anticipation of air-photo mapping in Trans-Jordan several ground control points were fixed. These took the form of road intersections, prominent rocky outcrops, isolated buildings, and points in villages which it was thought would be recognizable on the photos.

Provisional values for the section of the chain in Trans-Jordan had been computed originally by starting from the Palestine major stations near Beer-sheba. The co-ordinates of the subsidiary and ground control points were computed in the same terms. To obtain final values, a contour correction graph was drawn based on differences for the major points between the provisional and final values, and from this graph corrections were obtained for converting the minor points to their final values.

As photographs were not available when the minor points were fixed, sketches showing form lines, and drawn to an approximate scale of 1/25,000,

were made at each point, showing enough detail to ensure the subsequent identification of the air survey control points on the photographs.

The triangulations of Palestine and Egypt had been computed on different spheroids, Palestine being on Clarke 1880, and Egypt on Helmert's figure. Quite apart from differences based on the fundamental origins of the two systems, this fact affected the values of points between one system and the other along the common frontier. To change from the Egyptian Red grid to the Palestine grid near the grid junction it was necessary for the triangulation to be calculated on the same spheroid and, for this purpose, the geographical co-ordinates of the origins of the two grids were defined as being on Clarke's 1880 figure.

As stated previously, the Palestine-Trans-Jordan Chain incorporated a certain number of Egyptian stations along the frontier zone so as to enable a comparison of co-ordinates to be made. These included four geodetic stations and four third-order points of the Egyptian network. The co-ordinates of common points differed roughly by 120 metres in eastings and 30 metres in northings, this being largely owing to an initial error in the longitude of the Egyptian origin.

Palestine Transverse Mercator co-ordinates of the common Egyptian points in the Chain were first converted to geographicals on Clarke 1880, and these were then converted to Egyptian Red grid Transverse Mercator co-ordinates using Clarke 1880 tables.

Differences were then taken out between the resulting values and the corresponding Red grid co-ordinates in terms of the Egyptian triangulation on Helmert's figure. A contour correction graph was drawn from these differences to enable the Egyptian third-order points lying to the east of meridian  $33^{\circ} 30'$  E. to be converted to Red grid values in agreement with the Palestine network.

The co-ordinates of all Egyptian points lying to the east of the Palestine grid junction were converted to Palestine grid values after being first amended by the correction graph.

As the Egyptian triangulation was not in sympathy with the Palestine system it was necessary to provide overlap trig lists, and this was done for the area lying to the east of meridian  $33^{\circ} 30'$  E.

## Cyprus

A major triangulation of Cyprus was carried out between 1913-15, and subsequently a large number of third- and fourth-order stations were established, thus covering the island with a dense trig control. The records of the survey were kept by the Director of Land Registration and Surveys, who supplied all necessary data to the Director of Survey, Middle East.

The co-ordinates as originally supplied were in the form of rectangular Cassini co-ordinates in feet, computed on Clarke's 1880 spheroid, and referred to a true origin at Lat.  $35^{\circ} 00'$  and Long.  $33^{\circ} 19'$ . For military purposes these were converted from feet to metres, and a false origin taken in order to make all co-ordinates positive. The amended values represented co-ordinates on the Cyprus (Cassini) grid system. This Cyprus grid is an isolated one covering just the island itself, and a suitable extent of sea all around, and made a junction with the Mediterranean Zone, the Levant Zone and the Egyptian Red Belt. (See Diagram 2.)

It was perhaps unfortunate that, when the Cassini co-ordinates were converted to metres, they were not also amended to values on a Transverse Mercator

projection with the same true origin, as the latter projection is orthomorphic, and calculations on it may be carried out more easily.

The major triangulation consisted of a network of well-shaped triangles with an average side length of 10 to 15 miles, covering most of the island. The adjustment of the net was by the method of least squares in a single block, including condition equations introduced by two measured bases at Famagusta and Ktima.

The major net was broken down into third- and fourth-order systems, the points of the latter being about one to two miles apart.

Rectangular Cassini co-ordinates of the major and third-order stations were converted to the Cyprus grid and made up into trig lists corresponding to the 1/50,000 map series of the island. The fourth-order points, of which there were over 6,000, were not so converted, nor made up into trig lists, but the data, including their heights, were available if required for mapping purposes.

Observations were made between Cyprus and the mainland to connect the triangulation systems of Cyprus and Syria. The work was carried out by a section of 512 Field Survey Company R.E. under the direction of D.D. Survey Ninth Army in July and August, 1944. This connection ultimately formed a part of the Mediterranean Chain which was computed from Cyprus through Palestine, Egypt and Libya as far as Tunis.

### Aden

A record of the triangulation work carried out in the Aden Protectorate before 1932 is contained in a War Office Survey Paper entitled "The Triangulation of the Aden Protectorate 1876-1931." In 1927-28 an air survey of Aden was undertaken under War Office control, and further control points were fixed. In 1934 a Lambert conical orthomorphic projection was introduced in place of the Cassini previously in use.

Details of the projection and grid (Diagram 2) were as under:—

Spheroid.	Clarke 1880.
Projection.	Lambert conical orthomorphic.
True origin.	Lat. $15^{\circ} 00' 00''$ N. Long. $45^{\circ} 00' 00''$ E.
False origin.	1,500,000 m. west of true origin. 1,000,000 m. south of true origin.
Limits of grid.	<i>East.</i> $60^{\circ}$ E. meridian. <i>North.</i> Junction with the Mecca-Muscat grid on 150-km. northing line of the latter. <i>West.</i> Junction with the East African $5^{\circ}$ Belts along a loxodrome running down the middle of the Red Sea. <i>South.</i> A loxodrome in the Indian Ocean running more or less parallel with the coast of the Aden Protectorate and forming a junction with the East African $5^{\circ}$ Belts.

For the re-triangulation of Aden in 1931 a base line was measured and an azimuth observed, but although sufficiently accurate for local purposes, the triangulation was not suitable for possible extensions inland owing to the small triangles and short base.

A number of points variously fixed were used to control the 1934 air-photo survey of Aden. During 1932 astronomical fixations, including wireless longitude observations, had been determined at five R.A.F. landing grounds

near Aden. Other control was provided by Survey of India triangulation points, and some were astrolabe points fixed by the Royal Navy.

As the 1931 triangulation was unsuitable as a basis for extension to the north, a new network was observed during 1942 by an officer of the New Zealand Artillery to provide control for an area of about 300 square miles which was to be mapped from air photos to meet certain artillery requirements. It depended for scale on a new base measured in catenary. From the base extension, figures were built up to cover the area consisting of two quadrilaterals with triangular sides of 12 to 14 miles. These were broken down so as to give triangles of four- to five-mile sides, and numerous air-photo control points were fixed by intersections and resections.

The stations were permanently marked by angle irons set in concrete, and the observations, mainly on to helios, resulted in a mean triangular misclosure for the control net of under three seconds, and for the whole network of under four seconds.

### **The Mediterranean Chain** (See Diagram 5)

The Mediterranean Chain was the name given to the assembly of various networks of triangulation, both national and military, lying between Cyprus and Tunis which were connected together by the Survey Directorate, Middle East to form one continuous chain.

The fundamental origin adopted for the Chain was that of the Survey of Egypt at the Transit of Venus station on the Moqatta Hill at Cairo. Owing to local attraction in the prime vertical, the adopted longitude was corrected by + 3.45" throughout. Computations were based on the Hayford 1910 spheroid.

The complete Chain, which consisted partly of national triangulation networks and partly of work carried out by military survey units during the war, was subdivided into the following sections:—

- Section A. Cyprus-Syria connection.* The observations were carried out by a section of 512 Field Survey Company R.E. in 1944, between two points of the Syrian primary net and three points in Cyprus.
- Section B. Syrian Primary.* The triangulation used for the Chain was that part of the Syrian network known as the "Primary Meridional Chain," lying between Bonadi and the Palestine frontier.
- Section C. Palestine-Syria connection.* In 1944 a connection was observed between the Palestine and Syrian triangulations consisting of 27 points, including 13 Syrian primary points, and 6 primary stations of the Palestine survey.
- Section D. Palestine Primary.* A chain of quadrilaterals forming part of the primary triangulation of Palestine was used, the observed and adjusted angles being supplied by the Palestine Survey Department.
- Section E. Palestine-Egypt connection.* In 1941 observations by the South African Survey Company extended the Palestine major triangulation to connect with the Egyptian geodetic net.
- Section F. Egyptian geodetic triangulation.* The Survey of Egypt supplied geographical values for a chain of quadrilaterals extending from the Palestine border to the Cyrenaican frontier.



*Section G. Italian triangulation in Cyrenaica.* It will be remembered that two Italian triangulation systems (Eastern and Western) were found in Cyrenaica, which were eventually connected by observations carried out by 512 Field Survey Company R.E. Subsequently several first-order points of the western system were found, whose geographical co-ordinates were also given in terms of the eastern system, and these values were used for the computation and adjustment of the Mediterranean Chain in preference to the connection observed by 512 Field Survey Company.

*Section H.* This Section consisted of triangulation observed by military survey units to link up the Italian work in Cyrenaica with that in Tripolitania. It consisted of three sub-sections:—

H-1 observed by 46 South African Survey Company.

H-2 observed by 36 New Zealand Survey Battery.

H-3 observed by 517 Field Survey Company R.E.

In addition, a final connection between H-3 and Tripolitania was re-observed by 524 (Palestinian) Field Survey Company R.E., as the original connection was unsatisfactory.

*Section I. Italian triangulation in Tripolitania.* This Section extended as far as the Tunisian frontier, the final connection between the Italian and French systems being observed by 524 Field Survey Company in July, 1944.

*Section J. French triangulation in Tunisia.* Geographical values of stations were supplied by the S.G.A. in booklets corresponding to the 1/200,000 sheets. Only those following the coast from the Tripoli frontier to the area Tunis-Bizerta were used.

The general arrangement of the Chain is shown in Diagram 5 and the computation and adjustment was done by Mr. Cole of the Survey of Egypt. With the exception of the Palestine azimuth all measured bases and observed azimuths were taken into account.

The Palestine-Egypt connection revealed an azimuth error of E-P 16·4" which was confirmed by an azimuth observed in the area by the New Zealand Survey Battery giving a result of E-P 16·5".

The Palestine-Syria connection gave a difference in azimuth of P-S 13".

The combination of both the above gave a difference between Syria and Egypt of E-S 29·5". The junction between Syria and Cyprus computed from the Syrian values gave a difference of C-S 20·2" which indicated that the Syrian triangulation had an azimuth error of between - 20" and - 30". An adjustment was therefore made to the Syrian azimuths between the Palestine frontier and the Syrian points from which the Cyprus connection was made.

As a result of observations for the connection between Egypt and Cyrenaica it was established that the Italian azimuths were in error by approximate 50". In the readjustment of the triangulation the initial azimuth of the Italian side near Sollum was therefore corrected by - 50".

The Italian triangulation was then computed through to Derna, where it was found that the azimuth differed from that of the major triangulation by 48", and the net was adjusted to fit the major system. A scale difference of 1 part in 10,000 was evenly distributed from the base at Tobruk to the side at Derna.

Computation of the Italian major triangulation from Derna to Benghazi

gave an azimuth which agreed with the astronomical azimuth observed by the South African Survey Company.

The two bases measured by survey units at Agheila and Buerat were taken into account, and base and azimuth equations were put into the triangulation between those places. The remaining scale error was distributed between Buerat and the junction with the first-order network at Silma near the Tripolitanian frontier.

The Italian triangulation in Tripolitania was accepted for scale, position and azimuth, and corrections were applied to the geographical values to convert them from the Bessel to the Hayford figure. The connection between Tripolitania and Tunisia, which was observed by survey units, was satisfactory.

### **Geodetic research and field surveys in the Middle East**

The above gives a brief summary of the principal triangulation systems that either existed or were observed by military field surveyors for operational use in the Middle East. It should be noted here that although, for technical purposes, survey activities in Persia and Iraq came largely under Middle East control, the detailed account of them is given in Chapter VII. Most of the labour entailed in the preparation of the triangulation data for use in the field fell on the shoulders of the Trig Computing Section which formed part of the G.H.Q. Survey Directorate. Much research was carried out concerning the various national triangulation systems within the theatre. It was necessary to supplement the data which had been provided from War Office sources and this entailed personal visits to the Survey Departments concerned wherever and whenever they were accessible. During these visits, some of them necessarily of short duration, as much information and data as possible had to be obtained, and good relations and confidence had to be established and maintained.

It had, then, to be decided how best to utilize all this information and this entailed policy decisions on the grid systems to be adopted, the projection and figure of the earth to be used and, in some cases, the assimilation of several different triangulation systems on to one common basis.

The problems confronting the computing staff of the Survey Directorate were many and onerous. A few only are quoted to serve as examples of the tasks which had to be undertaken. The section was almost always working in a hurry against time and during frequent periods of great emergency they had to work day and night. The success of their labours cannot be too highly appreciated.

The following represent some of the typical jobs that were undertaken:—

- (a) Compilation of trig lists on the military grid covering the whole operational area of the Western Desert.
- (b) The conversion of captured Italian trig data from geographical to rectangular co-ordinates on the Libyan grid, and the preparation of trig lists.
- (c) The preparation of double-entry tables for the Egyptian Red and Purple grids on the Egyptian Transverse Mercator system.
- (d) The preparation of double-entry tables for the Libya Zone.
- (e) The conversion of Greek co-ordinates on two different projections to rectangular co-ordinates on the Mediterranean Zone Grid.

- (f) The preparation of tables for the conversion of trig values on Cassini projection to Transverse Mercator for use by the Survey Directorate in Palestine.
- (g) The preparation of reports on all the various triangulation systems within the theatre, with notes of guidance as to their use.
- (h) The preparation of Survey Technical Instructions and pamphlets on a multitude of technical subjects dealing with field survey methods, use of grids, computations, etc.
- (i) Preparation of conversion tables to enable co-ordinates on one system to be converted to another.
- (j) Preparation of geodetic tables to facilitate computations on the various figures of the earth, e.g., Helmert, Clarke 1880, Heyford, etc.
- (k) Computation of the principal programmes of major triangulation carried out in the field.
- (l) Preparation of contour correction graphs for the graphical adjustment and smoothing out of triangulations.
- (m) Miscellaneous computations such as those for "sheet corners" of maps, to enable map sheets to be gridded.
- (n) Computation of co-ordinates on the appropriate grid system and the preparation of trig lists for areas of actual or potential operations in the Western Desert, Libya, Tunisia, Greece, Sicily, Italy, Palestine, Syria, Trans-Jordan, and the Balkans generally.

The topographical sections of the field survey companies were continuously employed on survey work either in the field or in the subsequent work of converting the results of their field surveys into maps. Some of this work was centrally controlled under the G.H.Q. Survey Directorate; the bulk was, however, decentralized so as to come under the executive control of Survey Directorates with Eighth Army in the Western Desert, Libya and Tunisia, Ninth Army in Palestine, Syria and Trans-Jordan, H.Q. B.T.E., and H.Q. Palestine Base. There was also Tenth Army in Iraq and Persia whose work is dealt with separately. (See Chapter VII.)

Some examples of field survey work undertaken are given below:—

- (a) *Major and minor triangulation required for geodetic purposes.*
  - (i) Palestine–Trans-Jordan Chain (South African Survey Company and 36 New Zealand Survey Battery) to provide a connection between the networks of Palestine and Egypt and to give mapping control over that area.
  - (ii) The Trans-Jordan extension system. (Computation by the Australian Survey Company.)
  - (iii) The Cyprus–Syria connection (512 Field Survey Company R.E.).
  - (iv) The Syria–Trans-Jordan connection.
  - (v) The Palestine–Syria connection (512 Field Survey Company).
  - (vi) The connection between the Egyptian and Italian systems on the Libyan border (512 Field Survey Company).
  - (vii) The connection between the Italian Eastern and Western systems in Cyrenaica (512 Field Survey Company).

- (viii) The link up between the Italian triangulation in Cyrenaica and that in Tripolitania (46 South African Survey Company, 36 New Zealand Survey Battery, 517 Field Survey Company and 524 Field Survey Company).
- (ix) Connection between the Italian triangulation in Tripolitania and the French network in Tunisia (524 Field Survey Company).
- (b) *Establishment of ground control for mapping, etc.* In all accessible areas where there was a requirement for new mapping or revision on various scales, whether this was to be carried out by plane-tableing on the ground or by air survey methods in the office, there was a need for the establishment of ground control points. In most cases the triangulation framework already available provided fixed points which were usually too far apart, and it was therefore necessary to break down this control by fixing the positions of a large number of subsidiary points. The methods for doing this depended largely on the nature of the existing framework, the terrain conditions, and the circumstances under which the work could be carried out, that is to say, whether in the face of the enemy, as often occurred in Libya, or under more or less peaceful conditions. The technical methods depended on the scale and nature of the map which it was desired to produce. A rapid battle sketch map or a very small scale map clearly required less precise fixation of control than that required for a 1/25,000 map which would be used for artillery shooting. A few examples of field survey work carried out in the Middle East theatre are quoted below, simply to give an idea of the types of jobs which had to be tackled:—

- (i) Ground control in Egypt, Syria, the Levant, Trans-Jordan and Palestine for mapping at scales ranging from 1/25,000 to 1/250,000 (Australian Field Survey Company, South African Survey Company, 36 New Zealand Survey Battery, Royal Marine Survey Section, and 13, 19, 512, 517 and 524 Field Survey Companies R.E.).

This programme included intersection observations across the frontier into Turkey to enable data to be established for the gridding of Turkish maps. Technically this work was of a more or less deliberate nature which permitted the use of normal triangulation methods for breaking down from the existing framework to a lower-order control.

- (ii) Ground control in the Western Desert and Libya, for mapping, revision and other field use. Here the work was more of an active service nature, often in the near presence of enemy forces. Some of it was done by normal triangulation methods, and where this was not either feasible or justified, astronomical observations were taken, and many miles of car and compass traverse were completed.

The units principally engaged on survey work in the battle area, first of all with the Desert Army, and subsequently with Eighth Army, were the Mobile Echelon of 512 Field Survey Company R.E., the South African Survey Company, and 514 and 517 Field Survey Companies R.E.

A large amount of new mapping was undertaken on scales ranging from 1/12,500 to 1/250,000 for which ground control was needed, to cover areas for which either no maps existed, or for which

the available maps were unsatisfactory. For the larger scales deliberate triangulation was undertaken. For some of the small scale maps further west astronomical determinations were made, and further control established by car and compass traverses.

There were also large numbers of desert tracks which were beacons and surveyed. These tracks and beacons often formed the only recognizable features in an otherwise featureless desert, and their surveyed positions, when incorporated on the maps, proved to be of very great help to the troops. The occasional hills which were marked on the maps were labelled on the ground with their names and where no other specific topographical features existed in a bare area of sand and stones, artificial marks, often consisting of old tar barrels, were erected, surveyed and marked with their map references.

In those areas where it seemed likely that battles were imminent, and where no satisfactory medium or large scale maps existed, air photographs were asked for and, to convert these into maps, it was necessary to fix the positions of control points. On many occasions the area in question lay beyond our forward defence localities and it was necessary to send survey parties into no-man's-land and beyond, right behind the enemy lines. To effect this, armoured car patrols escorted the survey parties, and much valuable work was undertaken in this manner, though naturally at the cost of some casualties. Unfortunately it frequently happened that the only transport available to the survey parties was totally unsuitable for the class of work involved. The armoured car escort naturally disliked having to accompany 3-ton lorries into and beyond no-man's-land. They were slow and were visible over long distances. It is essential that transport, tactically suitable for the job in hand, should be made available on such occasions. It is also desirable that the vehicles should be equipped with radio so that information of enemy movement and instructions can be passed to them during critical periods.

Much valuable survey for mapping purposes was done by 512 and 514 Field Survey Companies R.E. in central Cyrenaica during the critical period of May, 1942, just before the German attack in the Bir Hakeim area which led to the British withdrawal into Egypt. It was with difficulty that the scattered survey parties were collected for the withdrawal.

During the preparatory weeks leading up to the battle of El Alamein the survey units of Eighth Army were working at full pressure. Owing to the shortage, at that time, of Royal Artillery Survey units, the South African Survey Company undertook a considerable amount of what was really artillery survey work in the El Alamein area. In preparation for the battle, 15,000 bearings were computed from their co-ordinates for the artillery. The preparation of the block-plots for use by the counter-battery officers has been referred to in Section 2. For their preparation a large amount of ground control was required between the coast and the Qattara Depression.

One great difficulty during battle in the desert was the location of position at night so that unit commanders could report progress. It was thought that this difficulty might be solved by attaching sur-

veyors to the attacking units so that they could observe back on to vertical searchlight beams installed in known positions. Traversing horizontal beams from signalling lamps were also to be used. Personnel of the South African Survey Company were trained in this work, but in actual practice, it was found that, owing to the fear of their attracting air bombing, the searchlights were not allowed to go far enough forward. In any case the dust raised by gun-blast and shell explosions was so dense that it is doubtful whether the beams could have been seen.

Survey parties did, however, accomplish much important work during the early stages of the battle, beaconing areas behind our forward troops, fixing start lines, and marking lines of advance.

During operations the R.E. Field survey units co-operated in the normal manner with the R.A. survey units in order to provide them with the necessary framework control required for artillery purposes. In this connection there were a few unfortunate cases where, owing to a lack of complete liaison between the two, the R.A. surveyors established temporary grids which were not in sympathy with the grid on the maps provided by R.E. Survey. This naturally caused considerable confusion and, what was more serious, a lack of confidence. The matter was, however, put right and thereafter co-operation was restored to its customary high level.

- (c) *Mapping and revision in the field.* In addition to the provision of ground control, the survey of topographical detail was required over large areas for new mapping, revision, and for the plotting of defence works, etc. Where air photographs of the right type could be obtained the compilation of such detail was largely achieved by air survey methods, but there was a necessity in many areas for plane-table surveys on scales of 1/25,000 and smaller.

Of historic importance were the surveys for 1/50,000 mapping in the El Alamein area. These were started in the spring of 1941 by the Mobile Echelon of 512 Field Survey Company and were continued later by the South African Survey Company. At its inception this work was regarded by some as an unnecessary and uneconomical use of skilled surveyors in view of the fact that the British forces were far in advance of that area, but there were no large or medium scale maps of that district and it obviously formed, between the coast and the Qattara Depression, the most important potential defensive bastion to Alexandria, Cairo and northern Egypt generally. Later events proved its value and, shortly before the battle in October, 1942, the Daba-Alexandria series at 1/50,000 was extended by further mapping, also surveyed by the South African Survey Company.

In the Western Desert, and further west in Libya, large mapping programmes were completed by survey units operating with Eighth Army. These included straightforward mapping on large, medium and small scales for the standard series, the mapping of defences, railways and pipe-lines, the preparation of sketch maps for battle use, etc. Much of this work was rendered difficult by the presence of uncharted minefields, and the surveys of minefields was another task which had to be undertaken. Apart from this new mapping, there was a continual

programme of revision in this western operational area, much of which entailed ground surveys.

In Egypt itself, although the maps available were considerably more adequate than elsewhere in the theatre, it was necessary to extend the 1/25,000 map coverage and, in addition, the revision of the existing map series, the surveys of camp sites and training areas, and the survey of defence works had to be undertaken. Though some of this work was done by the Egyptian Survey Department, the bulk of it fell to the lot of the field survey units.

In Palestine, Syria and Trans-Jordan very extensive mapping projects were taken up. Limited areas only had been surveyed before the war on the 1/25,000 scale, and there was by no means adequate coverage even at 1/100,000. Surveys on these and other scales were undertaken by British, Australian, South African and New Zealand Survey Units. After their formation the units composed of Palestinian personnel also took their share in the work, and there was a welcome contribution by French personnel of the Service Géographique based on Beirut.

Of much importance were the surveys along the Syrian-Turkish frontier, and also those covering areas of strategic importance for the defence of Palestine and Syria against possible attack from the north and east when the German forces were striking deep into Russia and the Caucasus. For certain specified "fortress" areas there were the additional surveys of defence works.

A study of unit war diaries and other reports reveals the fact that, on the average, the standard of training in plane-table work was poor. In several cases work which had previously been done by one unit had to be resurveyed by another. There is probably little doubt that plane-tiling is the finest possible training for a topographical surveyor. It instils in the mind a grasp of the essential fundamentals of detail and ground form which cannot be attained by any other form of training or instruction, and it is to be hoped that more attention will be paid to this fact in the training programmes for the post-war military surveyor.

(d) *Field surveys in the Sudan and Eritrea.* An account of the survey work carried out in connection with the campaign in East Africa is given in Chapter VI. The operations in Eritrea were, however, directly controlled by G.H.Q. Middle East, and therefore a reference will be made here to the survey activities undertaken in connection therewith. The survey unit concerned was 514 Field Survey Company R.E.

Almost immediately after its arrival from the United Kingdom this unit proceeded by road from Cairo to Khartoum. On its way it ran a compass traverse along the route from Shellal to Wadi Halfa controlled by astronomical fixations.

A road reconnaissance and quick survey from Aswan to Wadi Halfa was then carried out for the Chief Engineer, and a survey party was provided to determine astronomical fixes as a means of helping the R.A.F. to use the existing maps, which were of doubtful accuracy.

Triangulation work was then started to form a basis for carrying forward control with the force advancing to Keren, but not until the stand at Keren were the topographical sections able to keep pace with the advance. At Keren itself triangulation was carried out based on captured Italian data, covering our own gun positions and including

intersected points in the target area. A junction was then made backwards from Keren to the triangulation which had previously been started and abandoned owing to the speed of the advance.

Road revision of 1/50,000 maps of the Keren area was effected, and many other local road surveys and compass traverses were completed.

## SECTION 5. MAP SUPPLY AND DISTRIBUTION

As stated in Section 1, early in 1940 a Survey Directorate went out to G.H.Q. Middle East, followed shortly afterwards by two survey units, one of which was No. 2 Field Survey Depot R.E. on the standard war establishment of one officer and 18 other ranks. A large base map reproduction unit was also installed which, with the assistance of the civil Survey Departments in Egypt and Palestine, undertook large programmes of map production and printing covering the operational theatre. Stocks quickly mounted in volume and the Depot responsibilities were heavy.

The British offensive in the Western Desert against the Italian force which had crossed the frontier from Cyrenaica into Egypt opened in December, 1940. For these operations detachments from No. 2 Field Survey Depot were assigned to the A.D. Survey, Western Desert Force, and a sub-depot, carrying stocks for the Force was opened by G.H.Q. at El Daba. A.D. Survey (W. Desert) organized his own forward depots and mobile distribution units, using personnel of Field Survey units.

For the operations in Greece in February, 1940, No. 9 Field Survey Depot R.E. was available. It had been recently formed in the Middle East, and, although a number of its personnel were captured in Greece, it was later reorganized and equipped and sent to Palestine, where it came under the control of the Survey Directorate with the Palestine Force. Local Palestinian personnel were largely used when rebuilding this unit. By about the middle of 1940 the map distribution organization in Middle East was as under:—

- (a) *Under G.H.Q. control* and manned by personnel of No. 2 Field Survey Depot.
  - (i) Base Map Depot at Abbassia (moved later to Tura caves). This carried stocks of all maps in use in the theatre. It took delivery of all maps printed under G.H.Q. arrangements, and distributed them in bulk to sub-depots. It also made detailed issues to G.H.Q. troops.
  - (ii) G.H.Q. sub-depot, located at G.H.Q. This carried small stocks for issue to branches and staffs.
  - (iii) Alexandria sub-depot carried reserve stocks of all the Western Desert and Delta areas for the W. Desert Force and the B.T.E.
  - (iv) Moascar sub-depot. This was designed to split the stocks held at the Base Map Depot as well as providing for B.T.E. in the Canal Area.
- (b) *Under the control of A.D. Surveys, Western Desert.*
  - (i) El Daba sub-depot carried main stocks for the Western Desert Force and was manned by personnel of 2 Field Survey Depot.
  - (ii) Forward map depots at Bagush and Matruh.

- (iii) A mobile distribution unit for operating with the forward troops. This consisted of "A" Echelon of four vehicles fitted up as map stores, one of which was attached to the headquarters of each division or independent brigade; and "B" Echelon of two vehicles, to run a shuttle service between the Forward Map Depot and "A" Echelon.
- (c) *Under the control of D.D. Surveys, Palestine and Trans-Jordan.*
  - (i) Main Map Depot at Jerusalem.
  - (ii) Sub-depots at Gaza and Tel Aviv, mainly for dispersing stocks.
  - (iii) Forward Map Depot formerly at Nazareth, later moved to Syria.

Issues to units and formations under command of Western Desert Force and Palestine Force were made through the above-indicated channels under control of the Survey Directorates with those forces. Direct issues, under G.H.Q. arrangements, were made to British Troops in Crete and in Cyprus. Issues to B.T.E. were made from stocks held in the G.H.Q. Depot earmarked for them, under authority from H.Q. B.T.E.

It was the function of G.H.Q. Depots to hold reserves of all operational maps. These were made up of two parts:—

- (a) Those held immediately at the disposal of forward troops. The amount of these reserves was based on figures supplied by the formations concerned, viz.:—
  - A.D. Survey Western Desert Force.
  - D.D. Survey Palestine and Trans-Jordan.
  - H.Q. B.T.E.
  - H.Q. R.A.F. Middle East.
  - Fleet Hydrographic Officer.
- (b) Second-line reserves to enable the above figures to be maintained in the event of any sudden demand, without having to call for rush reprints.

The total reserves under the above headings varied between 2,000 and 8,000 copies of any one sheet.

During October the Base Map Depot was moved from Abbassia to the Tura Caves which had been prepared for use not only for the Depot but also for housing the reproduction plant of 512 Company as a safety precaution against air attack.

The entry of Japan into the war, with the consequent threat to Australia and British possessions in the Far East, resulted in the transfer of the Australian Corps from the Middle East. In connection with this move, the outline of the security organization and methods which were subsequently to be employed for all major overseas expeditions was evolved. A Port Detachment of one officer and six other ranks was installed at Suez. A code was prepared for the identification of sheets, and the maps were packed in code-labelled bales in No. 2 Field Survey Depot and despatched to Suez, all subsequent transactions being carried out in code to which only the O.C. troops of each ship had the key. This operation, which lasted for some weeks, was carried through with complete success and preserved the essential security of the move.

An event of considerable interest was the evolution of the "Army" type of Field Survey Depot for handling map supply and distribution to Eighth Army when it opened the second offensive into Cyrenaica towards the end of 1941. The operations were of a fast mobile character with long lines of com-

munication. The original Desert Army had passed through many trials and tribulations in the matter of map supply which could nearly all be attributed to the fact that the Survey Service, according to existing policy, was not officially responsible for distribution to divisions and had, as a consequence, neither transport nor sufficient personnel to carry out such a task. The Desert Army always had long communications and was very short of transport. Whenever the claims of maps came into conflict with other commodities such as rations or ammunition, the maps were invariably left behind.

In the early days of Eighth Army this trouble was temporarily overcome by the use of transport belonging to the South African Survey Company which had moved up from East Africa. Field-section personnel of this unit were used as a "stop gap" emergency measure for map distribution purposes. The unit was fully mobile, and since its drawing and printing sections had a static role in Cairo during the period in question, there was a temporary surplus of unit transport available. It was obvious, however, that this temporary arrangement could not last, and that a new type of unit must be formed, with sufficient personnel and transport of its own to keep the flow of maps going to the forward troops. The war establishment of No. 2 Field Survey Depot was therefore amended before the advance of Eighth Army through Cyrenaica to include six map distribution lorries, one for each of the four divisions and one for each of the two corps headquarters. These lorries held replacement maps for the formations, and maps of the areas immediately ahead of current operations. Arrangements were made for map stocks which emanated from the base map depot to be supplied by sending consignments forward by train, air, road or sea, whichever was most convenient, to advanced map depots located at Matruh and Tobruk. From here stocks were fed to a forward map dump near Army H.Q. in the field. At this forward map dump lorries were available, and the dump acted as a link between the base and advanced map depots and the formation vehicles. Maps of areas in advance of those for which the formation vehicles could carry maps were held by this dump, and its lorries were used to replenish the formation vehicles. Without the forward map dump and its lorries the organization would have broken down.

The above organization, modified in some details, was subsequently adopted for use by the British First Army in North West Africa, and by the British Second and First Canadian Armies during operation "Overlord" in Europe during 1944-45.