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SURVEY OF INDIA



PROFESSIONAL PAPER No. 23.

AIR-SURVEY OF WAZĪRISTĀN
1923 TO 1928

BY

CAPTAIN G. F. HEANEY R.E.

PUBLISHED BY ORDER OF
BRIGADIER E. A. TANDY
SURVEYOR GENERAL OF INDIA

PRINTED AT THE GEODETIC BRANCH OFFICE,
SURVEY OF INDIA, DEHRA DUN, 1928.

Price Eight Annas or Ten Pence.

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FOREWORD

This report does not pretend to put forward any new methods or advance in any way the science of air survey. It is only a record of work carried out under extremely difficult circumstances with the minimum of modern instruments.

This report covers the period 1923-28. All the compilation which it is possible to carry out with the existing fixed points has been carried out and mapped. To do this nearly all the photographs already taken have been used.

The work is, however, still going on. It is hoped that further points will be fixed by ground survey during 1928-29. Arrangements are being made to use the new F. 8 film camera in future. When the whole of the programme is complete an addendum to this report may be published.

AIR SURVEY OF WAZIRISTAN

1923—28.

Introduction

1. *Surveys prior to 1919.*—Prior to 1919 surveys in Waziristān extended as far south as the Tochi valley and as far north as Wāna and the valley of the Shahūr. These surveys were on the 2-inch and had been published on the 1-inch scale. The intervening area had been inaccessible to ground surveyors at the time the 2-inch survey was carried out, but the whole of it had been covered at different times by reconnaissance surveys, chiefly on the $\frac{1}{2}$ -inch scale. Triangulation, with the exception of a few fixed points, was non-existent and the old reconnaissance maps were too inaccurate to be of any use as a basis for air survey.

2. *Surveys 1919-20.*—On the commencement of the 1919 campaign a good map of the area of operations was required by the military authorities. A survey party was therefore attached to the force and all areas to which troops had access were surveyed and published on the 1-inch scale.

As the activities of this party were confined within the piquet line, the work was not so good as it might have been, had they been able to move about freely. No triangulation was carried out and it must at times have been extremely difficult for the surveyors to make good fixings.

3. *Air Survey 1922.*—When in 1922 it was decided to march a column from the Tochi valley to Makīn and to build a road, the existing small scale sketch maps of this area were found to be quite inadequate. As a good map was required before the commencement of operations and the country was inaccessible to ground surveyors, recourse was had to air survey and a map from air photographs was made by Major C. G. Lewis, R.E.

4. *Razmak Survey Detachment 1922-23.*—During the season 1922-23 a survey detachment was formed under Captain T. W. R. Haycraft, R.E., to carry out ground survey during the above operations. This detachment re-surveyed the area compiled from air photographs and found the work to be, on the whole, accurate. In addition it revised some of the 1919-20 1-inch surveys and extended its work over as much of the country as was then accessible.

5. Before this detachment had completed its work, it was realized that it would be impossible to extend ground surveys over large areas of which the political authorities and the R. A. F., required good maps, and that the only possible method of producing

these would be by the use of air photographs. Captain Haycraft was therefore sent to Dardoni to co-operate with the R. A. F. and carry out any survey possible.

6. *Air survey in the spring of 1923.*—Photographs were taken of areas round Ahmedwām and the Upper Dara Toi and compiled by Major Lewis and Mr. Muhammad Hasan in Mussoorie. These compilations were published as *appliqué* slips, and are certainly improvements on the existing maps, but have no claims to accuracy owing to the absence of fixed points. The Ahmedwām area was subsequently re-compiled after points had been fixed in it by Captain W. J. Norman, M.C., R.E. Parts of the Khaisara and Jalāl Khel areas were also photographed but it was impossible to make a survey owing to gaps in the photography and want of control points.

Captain Haycraft and his Detachment were withdrawn in June 1923.

7. In July 1923 a conference was held at Simla to consider the whole question of Frontier surveys, at which the General Staff, the Royal Air Force and the Survey of India were represented. At this conference the Army and Royal Air Force pressed for maps of Waziristān, which it was thought could be made from air photographs; and the Surveyor General agreed to send an officer to co-operate with the Royal Air Force in carrying out any work possible.

8. *Formation of the Waziristān Detachment.*—As a result of this conference the Waziristān Survey Detachment was formed in August 1923, with Captain Norman, in charge, and the latter proceeded to Dardoni early in September, where he lived with the Royal Air Force. It soon became apparent that nothing short of maps of practically the whole of Waziristān would satisfy the Political Department, the Army and the Royal Air Force.

As mountainous country, in the absence of a very close trigonometrical control, is unsuitable for air survey, the political authorities were again approached to see whether it might be possible to put ground surveyors into areas hitherto inaccessible. They stated that this might be practicable in the following areas:—

- (a) The Bhattami country.
- (b) The Khaisara valley, east of Asad Khel and north of the river.
- (c) The Shām valley.

The undermentioned areas were to be mapped from air photographs, together with any of the above which might prove inaccessible to surveyors.

- (d) The southern portion of the Khaisara valley.
- (e) The Shaktu valley and the area between it and the Tānk Zām including the Jalāl Khel area.
- (f) The Khaisara valley.

- (g) The Inzar valley.
- (h) The Upper Shinkai valley.

In addition it was decided that the Ahmedwām and Upper Dara Toi areas which had been mapped from air photographs in 1922-23 should be re-compiled, if it were found possible to fix additional control points in them. In April 1924 at the request of the Army the Shawāl valley was added to the above programme but this area has not yet been commenced owing to the impossibility of fixing any points in it.

In June 1924 a conference was held at Simla at which it was decided that, on the completion of areas (a) to (e) above, the existing maps of the following areas should be revised from air photographs.

- (i) The Baddar Algad and the country between this and the Dara Toi inclusive.
- (j) The Dhāna Toi basin and the Wāna plain.

Subsequently the idea of revising these maps was abandoned. The topography is good and as most of the inhabitants are nomadic, even were the map revised it would be impossible to keep it up to date without great expense.

9. *Ground survey 1923-24.*—The Bhattanni country was the only new area in which it was found possible to carry out ground surveys during the cold weather 1923-24. So items (b) and (c) had to be added to the air survey programme. Between November and March surveyors Khushāl Khān and Chirāgh Shāh, working respectively in South and North Bhattanni, surveyed a total of 360 square-miles on the 1-inch scale. Each surveyor had a permanent *badragga* of 60 men: the total cost being about Rs. 12,000/-.

10. The difficulties under which these surveys were carried out and the resolution and tact displayed by surveyors are illustrated by an incident which occurred to surveyor Chirāgh Shāh. The morning after his arrival in Bhattanni country, while he was preparing to go out to work, his camp was heavily fired on by the local inhabitants who resented his intrusion. Several bullets passed through his tent but fortunately there were no casualties. Chirāgh Shāh reported the matter but, as he was well outside the area occupied by the army, no assistance whatever could be given. However, to let him feel that he was not being forgotten and also to overawe the local people, it was arranged for a flight of aeroplanes to fly over his camp the following morning. On their doing so, one of the first sights that greeted their eyes was the familiar survey umbrella on a neighbouring hill top. Chirāgh Shāh was carrying on his work just as if nothing had happened. The sequel is even more striking; while the writer was looking through old papers to collect materials for this report, he came upon a letter written sometime later by surveyor Chirāgh Shāh to Captain Norman, requesting that the question of retribution for the outrage be allowed to drop, as he was then living,

as his guest, in house of the very Malik who had organised the attack, and he feared that any attempt by the Political Agent to impose a fine might only lead to further complications.

For his work on this and on a similar survey in Spīn Kamar under Captain Haycraft the previous year, Surveyor Chirāgh Shāh was awarded a Certificate of Honour.

11. An area of 82 square miles covering about 2 miles each side of the road between Manzai and Jandola also was revised on the 2-inch scale by the Detachment; and the new roads from Jandola to Sarwekai and from Drāband to Ghazni Khel via Tānk were incorporated in the existing 1-inch maps.

Since March 1924 all topographical maps of Wazīristān have been produced by air survey, which will now be dealt with.

APPRECIATION OF PROBLEMS

12. Before commencing a narrative of the work it will be as well to appreciate the survey situation towards the close of 1923.

13. *Unsuitability of the country for air survey.*—It must firstly be borne in mind that country such as Waziristan, which might aptly be described as a sea of mountains, varying in height from under 2,000 to over 11,000 feet, is altogether unsuitable for air survey, unless the very closest trigonometrical control can be provided. In his report on the air survey carried out by him in the Tochi-Razmak-Makin area in 1922, and referred to in para 3 of this report Major Lewis states:—

“It cannot be too strongly emphasised that in its present state of development, air-photo surveying is not a practical proposition for dealing with large areas of the North West Frontier”.

14. Since the summer of 1927 the Arundel, or resection method of compilation, has been introduced and it is possible that, given really good flying, and photography, the planimetry of air survey maps might be vastly improved, even with the sparse control usually available on the frontier. Contouring will still remain a difficulty owing to this paucity of height control points. Little of the flying has however been good enough for proper use to have been made of this method, even had it been known earlier.

15. In 1923 Captain Haycraft recommended that the country be mapped from obliques. This method although possibly possessing a future is at present not practical politics, as it requires very large numbers of fixed points, and very expensive and complicated plotting apparatus. The Canadian method of plotting from oblique photographs containing two fixed points and the horizon, is only applicable to flat country.

16. Major Lewis' work had, however, proved to be sufficiently accurate for the requirements of all ordinary map users, and as maps had to be produced somehow, his method of compilation, which is described in App. III of Chapter VIII of the Survey of India, Handbook of Topography 1926 Edition, was adopted for the more extensive air surveys commenced in 1923.

In order to minimise the distortions due to the rapid changes in relief, the photography was carried out from the greatest height which the aeroplanes available could reach i. e. 14,000—17,000 feet above M. S. L.

In addition some allowance for distortion due to relief was made when matching detail to join the photos into strips.

17. The work of an air survey may be conveniently divided under three headings.

- (a) Fixing of ground control.
- (b) Photography.
- (c) Map compilation.

We have just briefly considered (c) and before proceeding further we will consider the main factors effecting (a); (b) will be dealt with in the narrative of work.

18. *Conditions under which control was fixed.*—Ground control had to be fixed under active service conditions. The method employed was to visit hills overlooking the area to be surveyed and fix the positions of points by theodolite intersection. Each visit had to be arranged by the Political Officer; it was seldom possible to go more than 4 miles from a post, and a large tribal escort had to accompany the observer on every occasion.

19. *Difficulties affecting fixing of control.*—The time which could be spent on a hill was as a rule very short and there was often only time to measure angles by reading one micrometer on two swings. The stations from which points in unsurveyed country were fixed, had themselves to be fixed by resection, and owing to the paucity of the existing triangulation, and the difficulty of locating the exact point on a peak which had been previously fixed, this was often difficult; and the work could not reach a high standard of accuracy. If time permitted sun azimuths were observed: As far as possible two stations, from which the same points were to be intersected, were themselves fixed by resection from common points, and the mutual ray between the two was observed.

Many points had to be fixed by two rays only, so the sole check which could be applied against misidentification was the height. A few very distant points had to be fixed by intersections as acute as 3 degrees, but these had to be used in compilation for want of anything better.

The most useful points for compilation are those along or near the main rivers, and the majority of stations had to be sited with a view to seeing into particular valleys, a condition which seriously limited the choice of position.

NARRATIVE

FIXING OF CONTROL

20. *Ground work winter 1923-24.*—All control points were fixed by Captain O. Slater, M.C., R.E. and Captain Norman by theodolite intersections. In September 1923 the latter visited the ridge south-west of Kotkai on the Tānk-Zām—Inzar watershed and fixed two stations by theodolite resection. It was, however, found impossible to fix points in the Inzar valley which had been one of the main objects of the visit. In the same month he visited Kundi Ghar, the dominating hill north-west of Sarwekai, and resected three more stations. From two of these, points were fixed in the Khaisara valley and at Nānu and Peridai in the Shinkai Toi.

After this eight stations were visited on the hills each side of the Tānk Zām between Kotkai and Sora Rogha. These were connected, up into a system of triangulation and the whole located by resection. From this system points were fixed in the basins of the Shinkai and Sarwek and in the Umar Rāghza to the south, and the basins of the Shūza and Barāri to the north.

Later Captain Norman made two stations on the ridge, south of Piāzha, and fixed points in the Upper Inzar and Shinkai valleys and at Zadrana, four miles north of Piāzha.

Pairs of stations were then made on the ridge east of Kotkai, between the Razmak downs and the Shaktu, and near Idak on the Tochi-Khaisara watershed, and points were fixed from them respectively in the valley east of Kotkai, in the Upper Shaktu and in the Khaisara valley.

21. *The Shaktu Valley.*—To fix points in the valley of the Shaktu was one of the main problems, as, except for its upper portion, this could not be overlooked from any point accessible to a ground observer. As accurate compilation could not be carried out without some points in this area, it was decided to endeavour to fix them by observing an aeroplane flying over them.

22. *Observation to an aeroplane.*—The method was as follows:—

The observer, equipped with a wireless receiver, set up his theodolite at a known station. The aeroplane then flew over the station towards the point to be fixed and the observer picked up the machine and followed it with the telescope. On coming over the point the pilot sent the signal SSS-T on his wireless, and the observer then read one micrometer of his theodolite. The pilot continued straight on for one minute to allow the observer to finish his reading and pick up the aeroplane again, before it turned. The machine then turned and flew back towards the station, sending the same

message as he passed over the point. This manœuvre was repeated four times giving eight readings. The machine then went on to another point, the observer following it meanwhile with the telescope of his theodolite, and the performance was repeated. It was arranged that should the wireless break down the machine would "Zoom" over the point; this was once done and proved satisfactory.

Experience showed that four points could be observed from one station in two and a half hours flying, and that the aeroplane could be seen 26 miles from the theodolite.

Six points for fixing in the above manner were selected from vertical photographs, at intervals of about five miles, and four stations from which to observe them were fixed by resection. Each point was fixed by three rays, one of which was in each case from ground station number two. After computation, it was found that the average difference in the length of the common sides from station two to any point was 80 yards: the worst case being 120 yards.

One of the points thus fixed was quite close to a point latter fixed by ground observation, and its position was found to be plottably correct.

23. *1919 survey unreliable as control.*—When the ground control described above was fixed it was assumed that the 1919-20 work on the 1-inch scale would be good enough for control at the edge of the air survey.

When compilation was begun, however, this was found not to be the case, and great difficulty was found in reconciling some of this work with the photographs. Had its inaccuracy been discovered earlier, control points would have been fixed in the areas covered by this survey.

24. *Additional control.*—Since the winter 1923-24 no more control points have been fixed, and it has been possible to complete the 1923 programme with the aid of those fixed that winter, with the exception of the Shawāl valley, the Upper Dara Toi and the area between Razmak and Pir Ghal. In these areas there are not sufficient points to enable a compilation to be made with any hope of reasonable accuracy, and political conditions have not permitted ground observation; but at the time of writing, negotiations are being made with the political authorities which it is hoped will result in observers being allowed access to the Pir Ghal-Shuidar ridge, this year (1928). From here it should be possible to fix sufficient points to enable the greater portion of the Shawāl valley and the other remaining areas of the programme to be mapped.

PHOTOGRAPHY

25. All work had to be done by service machines, based on Dardoni and afterwards on Mirān Shāh, when the former had been abolished, and many of the areas to be photographed were a very

long distance from these aerodromes. The L. B. type of service camera taking boxes of 18, 5" by 4" plates, was the only one available for the vertical photography. This camera is very out of date for survey work but is still the standard camera of the R.A.F. in India.

The types of machine employed were the Bristol Fighter and the D.H. 9 A. As the first of these has a comparatively low ceiling, it is not very steady at high altitudes, and its petrol carrying capacity is limited, it is not a suitable machine for taking vertical photographs of a high country like Waziristān. The D.H. 9 A. is more suitable in these respects, but during the period under report the camera could only be fitted into it with the shorter side of the plate across the line of flight of the machine. This made the maintenance of lateral overlap between strips difficult and was a fruitful source of gaps. There was also no means of rotating the mounting in the machine to eliminate the "crabbing" effect caused by drift.

Photography had to be carried out by whatever R.A.F. unit was at Dardoni or Mirān Shāh and by whatever pilot happened to be available. Few of these pilots had any experience of air survey work and frequent changes of unit meant that, as a rule, pilots who had acquired a little experience and were getting to know the country were transferred, to be replaced by others who had to start again from the beginning. Compasses as then fitted to machines in this country could not be relied upon to give a course accurate to within 10 degrees and so are useless as survey instruments, and no special air survey instruments such as sensitive altimeters, wind gauge bearing plates for estimating drift, were available.

Before 1923 vertical photographs had been taken 10,000-13,000 feet above mean sea level and had generally been for the use of the R. A. F. or Political Department. They were as a rule in strips along rivers where there was cultivation or an inhabited area, and as few of these strips joined up, they were of little value for survey, so the whole country had to be re-photographed.

26. *Progress.*—Although an extensive programme of photography was decided on in July 1923, no vertical photographs were taken before December of that year owing to shortage of plates.

When finally begun, progress was very slow on account of:—

- (a) the limited supply of photographic plates,
- (b) aeroplanes being only available for photography after the demands of Army co-operation, bombing etc., had been met.

27. The shortage of photographic plates in the winter 1923-24 was particularly unfortunate, as Captain Norman was then living at Dardoni and the closest liaison was being maintained between him and the R.A.F. Also the majority of the pilots then in Waziristān had been there for a couple of years and knew the country intimately. By the time an adequate supply of plates was available, these pilots had been moved elsewhere and their successors

seldom remained long enough to acquire the same knowledge of the country or to obtain much practice in air survey flying.

28. From December 1923 to January 1925 inclusive rather over 6,700 photographs were taken, covering an area of approximately 650 square miles. The fact that an average of more than 10 photographs were taken for each square mile of country covered is an indication of the standard of photography and the enormous expenditure of photographic material. Even then the area photographed had numerous gaps all over it, which had to be filled subsequently, often with great difficulty and considerable expense of material.

29. In addition to the above obstacles in the way of good or rapid work, the very nature of Waziristān made the attainment of good results a matter of the greatest difficulty. The natural difficulties to be contended with can hardly be over-emphasised. The weather when clear enough for good photography can seldom be relied on. Thunderstorms, accompanied by squalls of wind and hail, seem to appear at a moment's notice, and flights often end in a race to reach the aerodrome before a storm. The temperature at high altitudes during the cold weather is arctic. Landing grounds are few and far between, and photography has often to be continued for hours over areas where, should the engine "cut out", a forced landing would most certainly result in a complete "write off" of the machine, if not of the injury or death of the occupants, and where, should they be fortunate enough to escape these, their safety, should they fall in the hands of the inhabitants, would be a matter of considerable doubt. On many days otherwise suitable for photography the air is so bumpy that it is impossible to maintain a machine on a even keel for long, and the strong winds at high altitudes, referred to elsewhere, have also generally to be contended with.

30. *The average scale* of vertical photographs was between four and six inches to the mile. A lens of 8-inch focal length was used as a rule prior to 1924, but after this a 6-inch lens was used to reduce chances of leaving gaps in the photography of any new areas, and to facilitate the filling of gaps in the areas previously photographed.

31. *Obliques.*— The ordinary oblique photograph required for intelligence work is generally taken from fairly low and close to the object photographed, and consequently is of little value for survey purposes. A new series of obliques had therefore to be taken for the identification of fixed points. This was done in the latter part of 1923, when Captain Norman was flown over the areas in which he had fixed points, and a series of obliques was taken to assist in the identification of these, and as an aid in the insertion of ground form lines on compilations.

Captain Norman proceeded on leave in April 1924 and was replaced by Captain Slater, who stayed at Dardoni till June when the Detachment was disbanded.

32. *Photography discontinued.*—As the R.A.F. were required for other more urgent work in Waziristān in January 1925, a complete stop was put to all survey photography, and it could not be resumed again till April 1926.

In the meantime No. 18 party which had been in abeyance as an air survey party since December 1924, was reconstituted with head-quarters at Murree, and permanent field head-quarters at Peshāwar, and took over the work of the Waziristān detachment. It had been decided that the air survey work should be incorporated in the standard Survey of India 1-inch sheets and that none of these sheets should be re-published till the whole of it had been covered by ground surveys on a 1-inch or larger scale, or compiled from air photographs.

33. *Policy in April 1926.*—In April 1926 air survey was in hand in ten 1-inch sheets, but in not one of these was the photography complete. The policy then, therefore, was to complete the gaps in as many sheets as possible, so that their publication might be proceeded with, before commencing to photograph any of the more extensive areas remaining.

34. *Subsequent progress.*—To give effect to this policy, Captain G. F. Heaney, R.E., the Officer in charge, No. 18 Party accompanied by surveyor Chirāgh Shāh proceeded to Mirān Shāh in April 1926 and co-operated with 20 Squadron in filling the gaps in the photography of sheets 38-H/13 & 15 and 38-L/1,2,3,5 & 6. Considerable progress was made, and by the end of May the photography of all these sheets was complete with the exception of a very small gap in the north-west corner of 38-H/15, which evaded all attempts at photography till March 1928.

In the autumn of 1926, the photography of the Pir Ghal area, and of the area lying between the valley of the Khaisara and the edge of the old but accurate ground survey, to the north-east of Wāna, was commenced, and by the end of December the latter area had been completed.

35. *The area round Pir Ghal* is the highest in Waziristān, parts of it being over 11,000 feet above sea level, and is therefore a very difficult area to photograph, and an even more difficult area to map from air photographs. At the time of writing the photography is nearing completion, but mapping cannot yet be commenced owing to the lack of fixed points referred to in para 24.

36. *The photography of the area north-east of Wāna* calls for special comment, as it was the largest area to be systematically covered with parallel overlapping strips of photographs without numerous gaps. The area actually covered was about 155 square

miles and in it there was only one gap, so small as to be negligible. One of the chief obstacles to contend with in Waziristān is the strong wind nearly always met with at high altitudes. Should this wind be across the line in which the strips have to be taken, it is extremely difficult for the pilot, without the aid of special instruments, to estimate the amount of his drift, and to fly on parallel lines backwards and forwards across the area. It is comparatively easy to fly along parallel lines in the same direction, but extremely difficult, if there be a strong cross wind, to fly along a line in one direction and then to turn round and fly back along a parallel line a short distance away from it. To obviate this difficulty all photographs were taken when flying in the same direction. Although this might appear at first sight to be an uneconomical method, the improved results obtained, and the absence of gaps, resulted in great economy in material, and probably also of flying time in the long run, and greatly facilitated the work of compilation. This work was carried out by a flight of 60 Squadron under Flight Lieut. J. W. Baker, M.C., D.F.C., R.A.F.

37. Previous attempts to solve the problem of flying parallel strips had been made.

Early in 1924, 31 Squadron discovered that at 15,000 ft. above M.S.L. there was a very strong steady wind from the north-west. It was found impossible to fly on parallel lines in both directions across this wind, so photography was carried out in a direction parallel to it. At first the strength of the wind was not correctly estimated, so longitudinal overlaps were bad, but later a ground speed of 120 m.p.h. down wind and 50 m.p.h. up wind was allowed for and the results were satisfactory.

It is not, however, always possible, in view of the shape of the area or the positions of features, to arrange to take strips in a direction which will conform with the prevailing wind, and so this system, although successful in a particular case, could not be universally applied.

Probably the most successful single flight of the whole survey was made by F. O., N. V. Moreton, R.A.F. of 31 Squadron who early in 1924 photographed an area of 65 square miles in one flight with a Bristol Fighter machine.

COMPILATION

38. Compilation was carried out on the 1½-inch scale. Reference has already been made in para 16 to the method, which is that originated by Major Lewis in 1922. The principle followed was to select strips or areas in which there was plenty of control, generally along the larger valleys, and to "put down" these first. When this detail had been transferred to the compilation, it was considered as fixed, and was used where necessary as control for

“laying down” the photographs of the intervening spaces in which there might be few or no points fixed by ground survey.

The following shows how the various areas were laid down:—

- (a) The strip along the Shaktu river was put down on the points fixed by observation to an aeroplane. (See para 22).
- (b) The Shūza was put on the points fixed by theodolite intersection.
- (c) The Tānk-Zām and Baddar valleys were made to agree as nearly as possible with the 1919 survey.
- (d) The area between the Tānk-Zām and the Shūza valley on the south and the Shaktu on the north, was filled in by fitting in strips between the work in these areas, taking into account a few additional fixed points, such as a tower in the Piāzha valley, three towers in the Barāri Algad, the intersected point Nishpa Ghar, and a few points in the Shaktu valley.
- (e) The area between and including the Spli Toi and the Shinkai was put down on points fixed at Nānu, Peridai, Ahmedwām and in the Tsenalai valley, south of Ahmedwām.
- (f) The Upper Shinkai and Dwe were put down between the area (e) and a few points near Karama.
- (g) The Upper Inzar and the Sarwek were put down on a few points near Warza and a tower in the Sarwek valley.
- (h) The lower Inzar and the Umar Rāghza were put down between the Tānk-Zām on the north and east, area (g) on the north-west, and area (e) on the south and west.
- (j) The centre of the Khaisara valley was put down on points fixed in it.
- (k) The area south-west of the Khaisara valley was put down between area (j) and the old survey of the Wāna area.
- (l) The north end of the Khaisara valley was put down between areas (j) and (k) and a few fixed points on the Khaisara-Shawāl watershed.
- (m) The area between the Khaisara and the Baddar was put down to fit between areas (e) and (j).
- (n) The Jalāl Khel area was put down between the Shaktu on the north, the Shūza on the west and south, and the ground survey of Bhattani country on the east, with the help of a few old triangulated points in the centre.

- (o) The Khaisara and Shām valleys were put down between the surveyed areas in the Upper Khaisara and the Tochi on the north, and the Shaktu on the south, corrected by some intersected points in the Khaisara area.
- (p) The Gurgura valley was adjusted to fit the surrounding areas already compiled.

39. *The delineation of hill features* by means of form lines was commenced in June 1924 and by October had caught up with the compilation of outline, since when the two have been carried on *pari passu*. A complete stereoscopic examination of the whole ground was impossible owing to insufficiency of overlap. The most rapid method of working was found to be, to make a rough form-line compilation from verticals and revise it with the assistance of oblique photographs. The lack of fixed heights was very much felt.

40. *Names* were as a rule given by the local Political Agent. The best method was found to be to deal with one valley at a time. A sketch map was prepared and this, together with the vertical photographs of the inhabited portions of the valley and any oblique photographs, were sent to the Political Agent concerned, who ascertained the names by questioning the local people.

The Branch Intelligence Officer attached to the R. A. F. at Dardoni, Captain R. C. Macpherson, was of the greatest assistance in the early stages of this work, and did much in the way of preparing sketch maps which would otherwise have devolved on the survey party.

41. *Compilation from 1924 onwards.*—When the Waziristān Detachment was disbanded in June 1924, Captain Slater and Surveyor Chirāgh Shāh proceeded to Simla, and that autumn to Dehra Dūn, and afterwards Peshāwar, carrying on their compiling work as photographs were received from the Royal Air Force. As stated above, survey photography was altogether discontinued in January 1925, and by March of that year, all the photographs received had been incorporated in the compilations. From then till April of the following year nothing could be done.

42. *Personnel employed.*—From March 1926 to May 1928 Captain Heaney has been in charge of No. 18 Party, but the actual work of compilation has been carried on, as far as possible, by Surveyor Chirāgh Shāh, whose knowledge of the country, gained on ground surveys with the Razmak Survey Detachment in 1922-23, and with the Waziristān Survey Detachment the following year, and acquaintance with the air survey work from its beginning, rendered him invaluable. In the autumn of 1926 Mr. Muhammad Hasan compiled a large part of the area then photographed, south-west of the Khaisara.

43. Waziristān is now in the area of No. 1 Wing R. A. F. with head-quarters in Peshāwar, and the situation of the field head-

quarters of No. 18 Party in the same place made the closest co-operation possible between the Officer in charge and Flight Lieut. S. J. Smetham, R.A.F. the Photographic Officer attached to No. 1 Wing R. A. F. This officer has directed all photographic work from March 1926 to March 1928 and he deserves much of the credit for the success of the survey during this period.

44. *Mapping.*—As soon as the compilation was completed by 18 Party, the work was handed over to "A" Company, sheet by sheet, for fair mapping.

The following sheets were completely re-drawn incorporating the air survey.

38 H/11 and 15

38 L/1, 2, 3, 5 and 6.

The air survey was added to the old fair sheet of 38 H/13 but, as this was not immediately required, the sheet was entirely redrawn in No. 6 Drawing Office.

While this drawing was in hand, maps of the Upper Shaktu valley and of the area between Razmak, Sarwekai and Wāna were required by the Army. These maps were made from the partially completed fair sheets, being printed in black and brown only.

The compilation in sheet 38 H/14 was not complete (see paras 24 and 35). All the compilation which it had been possible to carry out had been incorporated in the special Razmak-Sarwekai Wāna map. It was therefore decided to postpone the redrawing of the fair sheet.

A small portion to the south of sheet 38 H/10 had been compiled and it was not expected that the whole sheet would be completed for some years. The new air survey was therefore drawn as a mask for the old fair sheet, so that a new edition of the map could be published incorporating the new work.

The first of the sheets of which new editions could be published (i.e., 38 H/10,11,13 and 15 and 38 L/1,2,3,5 and 6) was submitted for publication in June 1927 and the last was submitted by August 1928.

DISCUSSION OF DIFFICULTIES & METHODS

45. *Photography.*—The difficulties to be contended with in taking the photographs have already been referred to and so will now be only briefly summarized. They may be divided into two classes:—

- (a) Those inseparable from the photography of a hostile and mountainous country with an uncertain climate like Waziristān.
- (b) Those due to lack of continuity and of special training of personnel, shortage of material, and unavailability of machines for photography when required.

Of (a) no more need be said. Of (b) it may be said that many of these are hard to avoid when working with service pilots and machines, as flying for survey photography is only one of the many branches of his profession in which a service pilot has to be proficient. Also in a country in a state of unrest like Waziristān the calls for photographic material and for machines for purposes other than survey are uncertain and may be urgent, so it is difficult to arrange for a sufficient supply of plates to be always available, or to allot machines for photography whenever the weather is suitable.

It is felt, however, that the best results will not be attainable until it is possible to allot definite machines, personnel and material exclusively for survey work, either for a definite period when work has to be done, or until a particular piece of work has been finished.

46. *The method of compilation* used is not a precise one, and its accuracy depends directly on the skill of the compiler, the number of fixed points available, and the quality of the photography; but no improvement in method can be effected without very much better flying and photography. As stated in para 14 when both these have been attained the Arundel resection method should give greatly improved results.

47. *Heights.*—Hills will still remain a difficulty even could the resection method be used, as, without a sufficient height control, any system of attempting to show the relative heights over a large area, rapidly degenerates into guess work. Even with the new topographical stereoscope fitted with parallaxic grids which has only arrived from England while this report is being written, at least four fixed heights per photograph would be necessary before satisfactory contouring could be attempted. Nothing short of rigorous ground survey, by planetable or photo-theodolite, can at present give a true representation of such mountainous country.

48. *Probable errors.*—Until a rigorous survey of the country can be made it will be impossible to test the accuracy of the work,

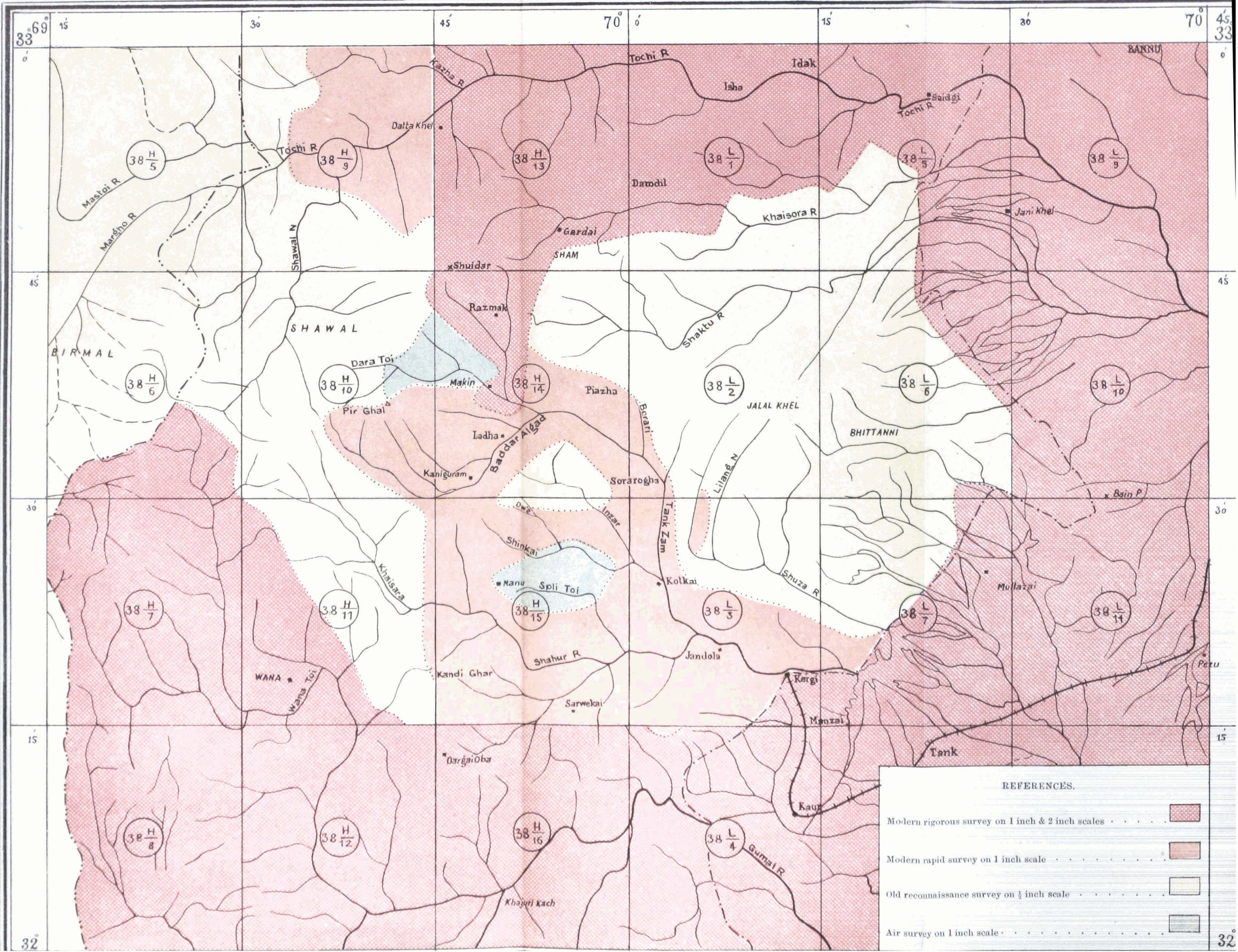
and until then the question of probable errors must remain largely one of speculation. The discrepancies, however, met with in compilation, between positions of the same point fixed from different strips, do give some indication of the error. This may also be gauged to some extent from that found in Major Lewis' work round Razmak in 1922 and in the work carried out on the survey tactical exercise in 1927.

Keeping this in mind, the probable error between the map position of a point and its correct position relative to local control points, under conditions such as in the Khaisara and Shuza valleys [Areas (j) & (b)] may be put down as in the neighbourhood of 100 yards in the valleys and twice this amount on the tops of hills. In these areas control points, on the average 2 miles apart, were fixed to within 10 yards *inter se*, but the whole control may be displaced 100 yards from its true position.

In areas where there is less control i. e. up to 5 miles between fixed points, the probable errors are much greater, but it seems unlikely that there is an error in the absolute position of any point of more than 500 yards, and there are probably few areas in which the error is as much as this.

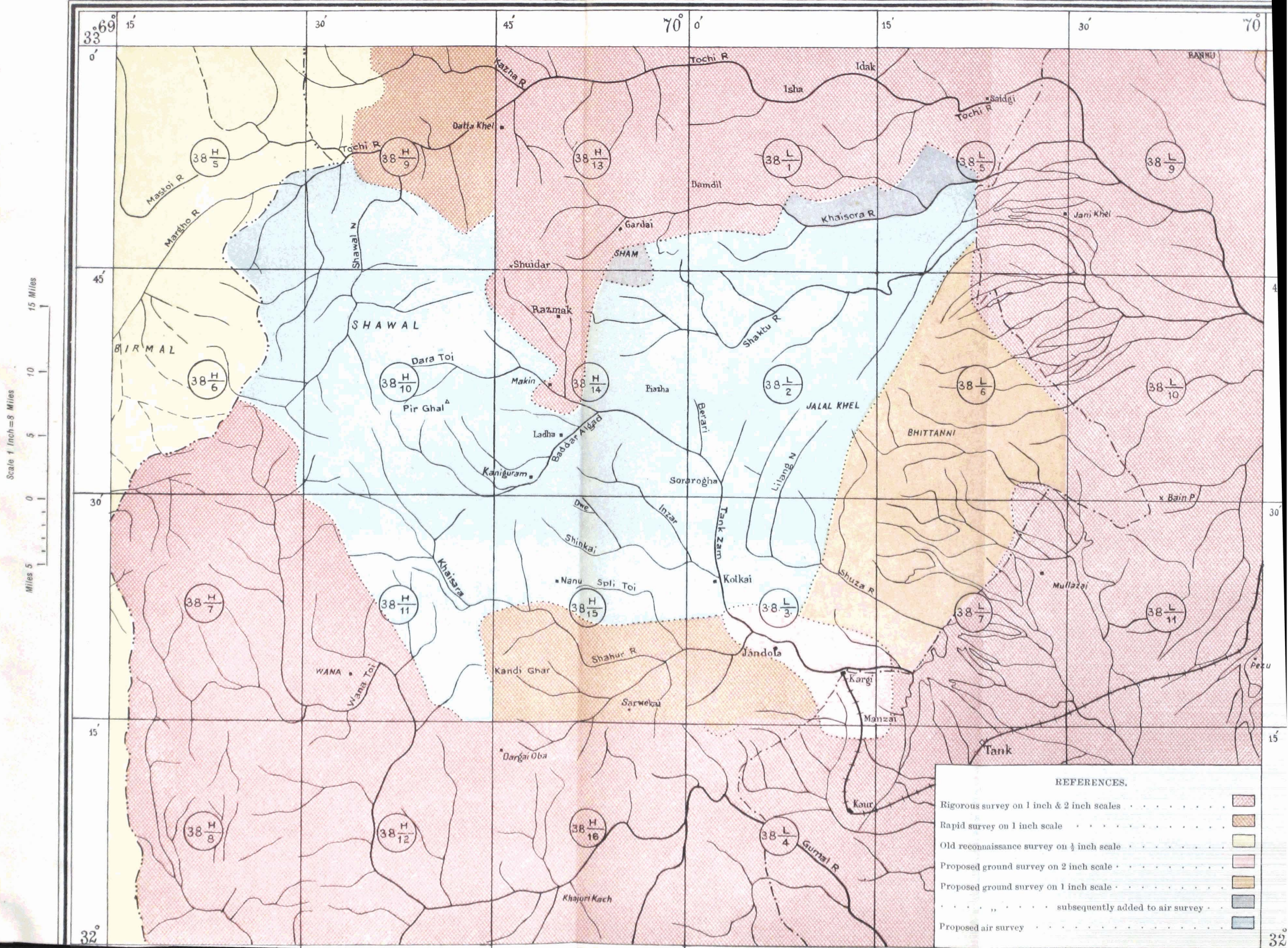
As errors are largely cumulative, they will not as a rule be considerable between places a short distance apart; and as the shape of features in the air survey map can always be represented with considerable accuracy, ordinary map users are not likely to be much affected by slight displacements of areas from their true positions.

Scale 1 Inch = 8 Miles
Miles 5 0 5 10 15



REFERENCES.

Modern rigorous survey on 1 inch & 2 inch scales	
Modern rapid survey on 1 inch scale	
Old reconnaissance survey on 1/2 inch scale	
Air survey on 1 inch scale	



Scale 1 Inch = 8 Miles
 15 Miles
 10
 5
 0
 5
 1
 Miles

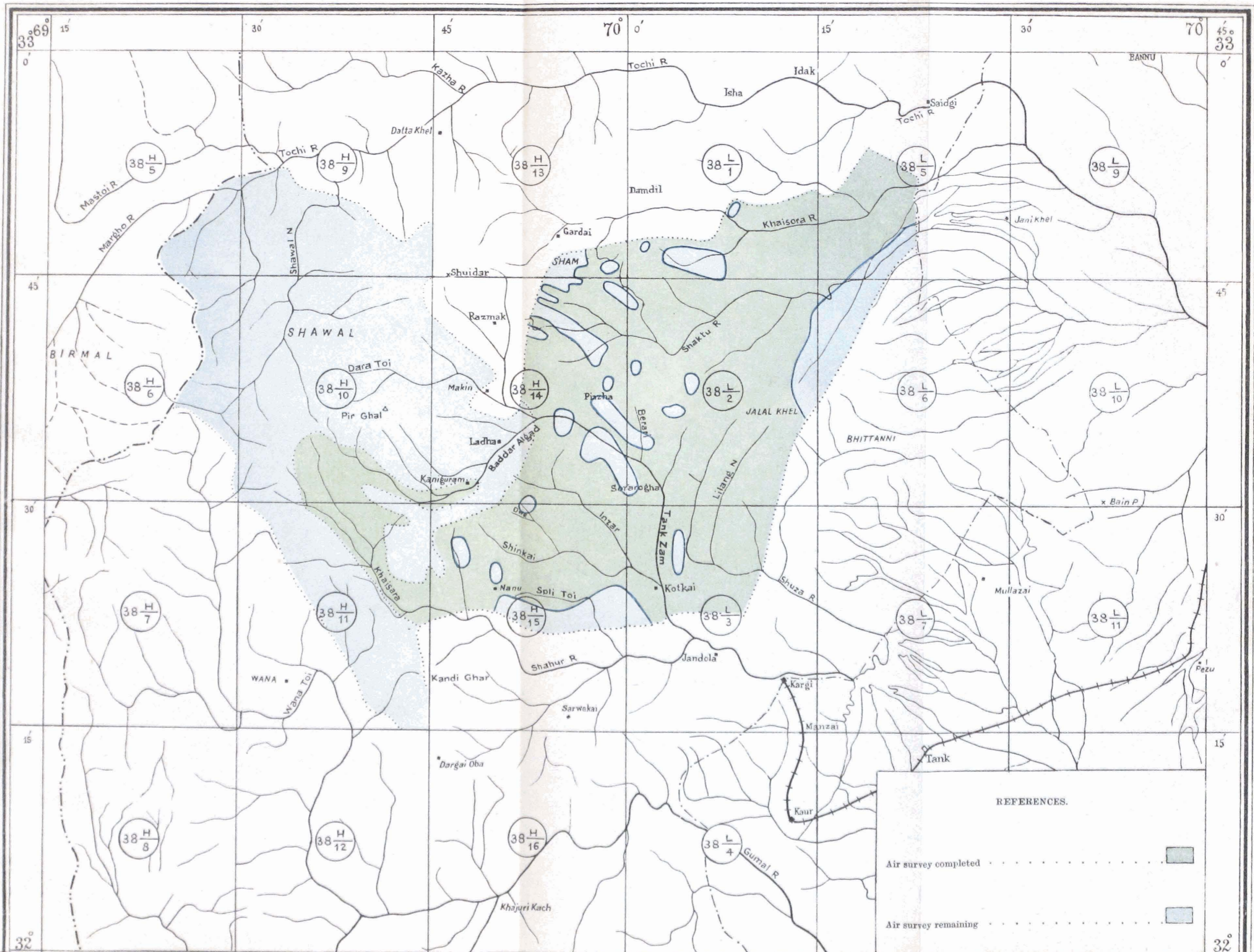
REFERENCES.

Rigorous survey on 1 inch & 2 inch scales	
Rapid survey on 1 inch scale	
Old reconnaissance survey on 1/4 inch scale	
Proposed ground survey on 2 inch scale	
Proposed ground survey on 1 inch scale	
..... subsequently added to air survey	
Proposed air survey	

33° 0' 15' 30' 45' 70° 0' 15' 30' 70°
 45'
 30'
 15'
 32°

0' 15' 30' 45' 60' 75' 90' 105' 120' 135' 150' 165' 180' 195' 210' 225' 240' 255' 270' 285' 300' 315' 330' 345' 360'

Scale 1 Inch = 8 Miles
Miles 5 0 5 10 15

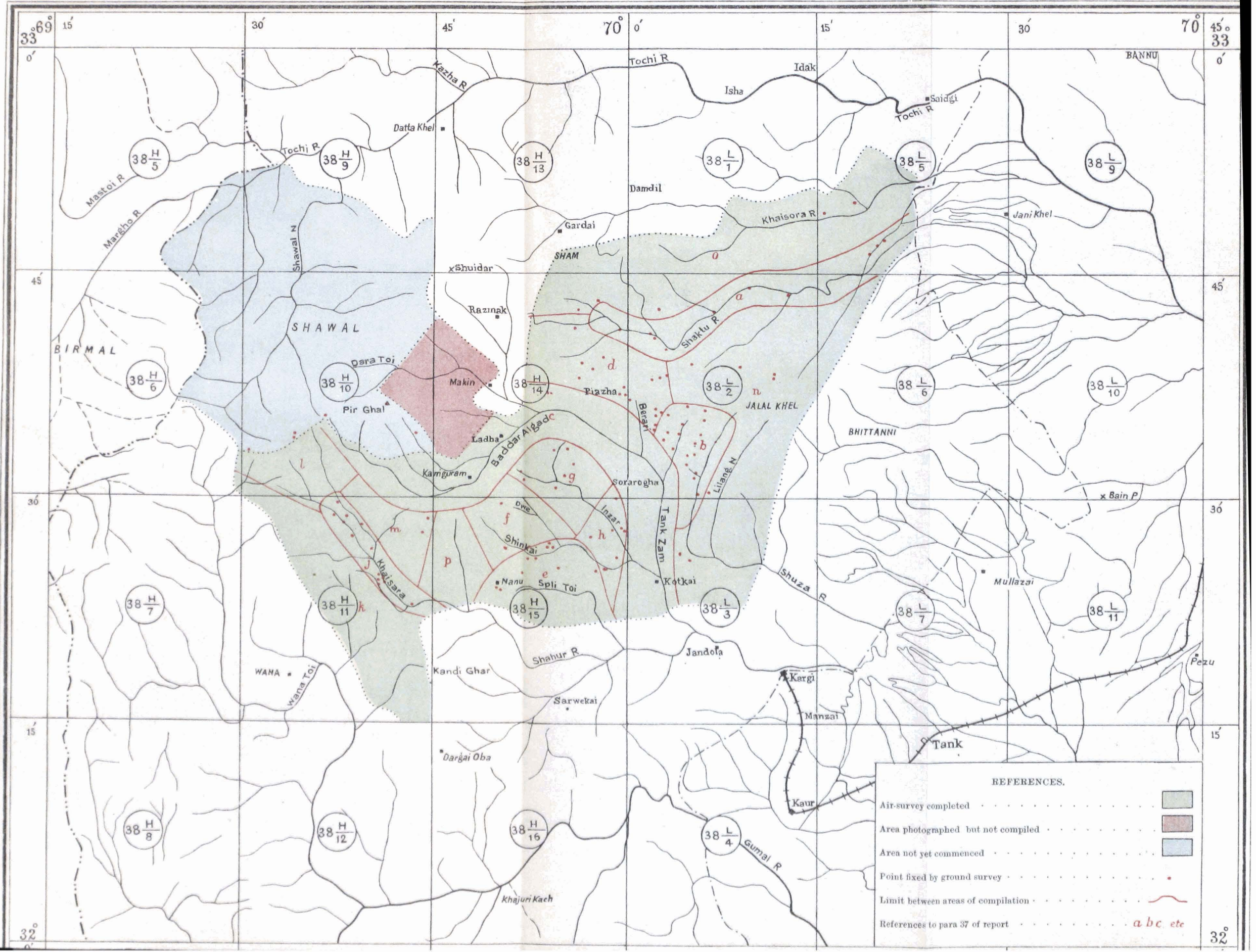


REFERENCES.






Air survey completed

Air survey remaining

Scale 1 Inch = 8 Miles
15 Miles
10
5
0
5
Miles



REFERENCES.

Air-survey completed	
Area photographed but not compiled	
Area not yet commenced	
Point fixed by ground survey	
Limit between areas of compilation	
References to para 37 of report	<i>a b c etc</i>