REPORT

on

Aeromagnetic Surveys in the Kingdom of Afghanistan

executed for

BUNDESANSTALT FÜR BODENFORSCHUNG
Hannover
Germany

by

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Contents

Enclosures

1	Position of Survey	Scale 1:5 000 000
2	Layout of Survey (with Sheet Index for 1:200 000 Maps)	Scale 1:2 000 000

Aeromagnetic Reconnaissance Survey-
Isanomalies of the Total Magnetic Field, Scale 1:1 000 000

3 Compilation Map, Western Part, Survey Areas 4 - 14

4 Compilation Map, Eastern Part, Survey Areas 1 - 3

Aeromagnetic Reconnaissance Survey-
Isanomalies of the Total Magnetic Field, Scale 1: 500 000

5 Compilation Map, Survey Areas 7, 12, and 14

6 Compilation Map, Survey Areas 7, 8, 11, and 12

7 Compilation Map, Survey Areas 6, 7, and 9

8 Compilation Map, Survey Areas 1, 4, and 9

9 Compilation Map, Survey Areas 4 and 5

10 Compilation Map, Survey Areas 1, 2, and 3

Aeromagnetic Reconnaissance Survey-
Isanomalies of the Total Magnetic Field, Scale 1: 200 000

11 Sheet 420, Survey Areas 11 and 8

12 Sheet 602, Survey Area 11

13 Sheet 415, Survey Area 8

14 Sheet 421, Survey Areas 8 and 11

15 Sheet 603, Survey Areas 7, 8, 11, and 12

16 Sheet 609, Survey Area 12

17 Sheet 410, Survey Area 5

18 Sheet 416, Survey Area 5

19 Sheet 422, Survey Areas 7 and 8

20 Sheet 604, Survey Area 7

21 ~~Sheet 610, Survey Areas 7, 12, and 14~~
22 Sheet 411, Survey Area 5
23 Sheet 417, Survey Areas 4 and 5
24 Sheet 423, Survey Area 4
25 Sheet 605, Survey Areas 7 and 9
26 Sheet 611, Survey Areas 6, 7, and 9
27 Sheet 617, Survey Area 6
28 Sheet 418, Survey Areas 4 and 5
29 Sheet 424, Survey Areas 1 and 4
30 Sheet 606, Survey Areas 1, 4, and 9
31 Sheet 612, Survey Areas 6 and 9
32 Sheet 618, Survey Area 6
33 Sheet 519, Survey Areas 1 and 4
34 Sheet 701, Survey Area 1
35 Sheet 707, Survey Areas 1 and 9
36 Sheet 520, Survey Areas 1 and 2
37 Sheet 702, Survey Areas 1 and 2
38 Sheet 515, Survey Areas 2 and 3
39 Sheet 521, Survey Areas 2 and 3
40 Sheet 703, Survey Area 2
41 Sheet 516, Survey Area 3
42 Sheet 522, Survey Areas 2 and 3
43 Sheet 704, Survey Area 2
44 Sheet 517, Survey Area 3

<u>Aeromagnetic Detail Survey (Survey Area 14)</u>
<u>Isanomalies of the Total Magnetic Field, Scale 1:50 000</u>
(Mainly located on the following sheets)

45 Sheet 610-D-I+III,
46 Sheet 610-D-II+IV,
47 Sheet 610-F-I+III,
48 Sheet 610-F-II+IV,
49 Sheet 616-B-I+III,
50 Sheet 616-B-II+IV,
51 Sheet 616-D-I+III,
52 Sheet 616-D-II+IV.

Areas for Harmonic Analysis, Scale 1:1 000 000

53 Aeromagnetic Reconnaissance Survey,
Western Part, Survey Areas 4 - 14

54 Aeromagnetic Reconnaissance Survey,
Eastern Part, Survey Areas 1 - 3

1. General

1.1. Purpose of Survey and Location of Survey Area

On behalf of the "Bundesanstalt für Bodenforschung", Hannover, PRAKLA, Gesellschaft für praktische Lagerstättenforschung GmbH, Hannover, executed aeromagnetic surveys in Afghanistan in 1966.

Purpose of the aeromagnetic surveys was the more detailed investigation of the sedimentary basins in the south-eastern and southern part of Afghanistan, as well as the localisation of possibly existing magnetic deposits.

The survey area comprises the major part of southern Afghanistan, location and boundary lines are represented on enclosure 1, scale 1:5 000 000.

1.2. Topographic Maps

The positioning of some reference points on the flight lines was performed by means of provisional topographic maps in the scale of 1:50 000, so called Advance Copies. These maps are containing the preliminary evaluation of already existing photogrametric surveys of Afghanistan. During the course of the surveys the final edition of the topographic map had not already been on hand.

The places, roads, streets, and other geographic information entered on the situation maps were taken from the Advance Copies. The names of the places have been obtained from the international aeronautical chart in the scale of 1:1 000 000.

~~2. Execution of Survey~~

2.1. Duration of Survey and Performance

Starting from Kandahar, the aeromagnetic surveys were carried out in the period of August 8, 1966, up to November 29, 1966. A total of 55 941.5 profile kilometers was flown which is corresponding to an average of 491 km per day. Because of the partly very extended connecting flights from Kandahar into the individual survey areas, the ratio of productive length to the total length flown was 1:2.08, only.

2.2. Party Staff and Equipment

2.2.1. Instruments and Devices

2.2.1.1. Navigation Instruments

Doppler Navigator

A Radan-Doppler-System, type GPK 1000 (manufacturer General Precision Laboratories, Pleasantville, N.Y.) together with a flight path computer TNC 50 of the same company, in combination with a precision gyro-compass Kearfott J4 served as pilot's aid for horizontal navigation control and later positioning of the flight lines.

Altimeters

A barometric altimeter (manufacturer PRAKLA) with electric continuous recording was used to measure the altitude of the plane above sea level. The additionally installed electric radio altimeter HG 90-50 (manufacturer Honeywell) for the measurement of the height of airplane above ground mainly could not be used as the flight altitude generally exeeded its range of 1500 m.

Flight Path Camera

The flight path camera LK 21 was manufactured by PRAKLA. This strip camera prepares continuous strips of the overflown terrain in the scale focal length/ flight altitude. The camera is mounted on a gyro-stabilized platform in order to guarantee a constantly sharp representation on the film.

The fiducial marks for the synchronization of flight path and magnetometer surveys are represented by simultaneous recording of the Doppler coordinates on the magnetometer tapes and on the marge of the film. On the film, the first "1" indicates the exact position of the fiducial. It is followed by 4 digits indicating the flown profile length, and 3 more digits which give the actual deviation of the aircraft from the desired line of the profile (both figures in hundredths of Doppler-miles, see 2.3.1).

2.2.1.2. Magnetometer

On board the aircraft and for the ground station, the PRAKLA proton-precession magnetometers PM 24 were used. The duration of one single measurement is 0.9 sec, the minimum indication is 1 γ.

The mean square error of one measurement is smaller than ± 1 γ.

2.2. Personnel

The party consisted of:

1 Party Chief
3 Interpreters
1 Pilot
1 Co-Pilot/Navigator
2 Operators
1 Aircraft Mechanic

In the head office in Hannover, 6 interpreters and draftsmen, and 3 computer operators were working on the further evaluation of the data.

2.2.3. Aircraft

A twin-engined aircraft (each engine 380 HP), type Aero Commander 680 F, with a maximum endurance of 8h was used. The aircraft was equipped according to instrument flight regulations, thus making starts and landings possible also during bad weather.

2.2.4. Vehicles

For all necessary transports the party of PRAKLA disposed of a VW-pickup, and was equipped by the Ministry of Mines in Kabul with 2 jeeps and drivers.

2.3. Survey Technique

2.3.1. Disposition of Survey

According to the task, the area to be surveyed was subdivided into 12 individual survey areas, i.e. into the areas 1 to 9, 11, 12 and 14 (see encl. 1 and 2). The survey areas have been surveyed in the sequence of their numbering. Because of the fact that the results of the survey had to be delivered as early as possible, the respective survey areas had to be evaluated individually - just after the termination of the flights (see 3.2.2, Calculation of the Regional Fields).

With the exception of survey area 14, the direction of the survey lines in all areas was W 50°N. Their line spacing was 5 km. The control lines were flown rectangular to the survey flights, their spacing being 20 km. This flight pattern is corresponding to the requirements for the determination of the dimensions of the sedimentary basins.

Because of different heights of the terrain, the flight level in the individual survey areas was fixed as follows:

~~Areas 3 and 5 constantly 3400 m above MSL;~~
Areas 2 and 4 constantly 3000 m above MSL;
Area 1 constantly 2600 m above MSL;
Areas 6,(7),8,9,11,12 constantly 2000 m above MSL;

The direction of the survey lines in area 14 was N-S, line spacing being 1.2 km. The control lines were flown rectangular to the survey lines with a spacing of 10 km. This flight pattern is corresponding to the requirements for the detection of possibly existing ore deposits. The flight height was fixed to 1500 m above MSL, however, caused by a mountain crest, 2000 m above MSL were partly reached in the southern part.

The speed of the survey flight in all areas was 255 ± 15 km/h, according to 71 m/sec.

The exact flight line positioning resulted in a gradually increasing of the Doppler mile from 1880 m to 1913 m.

2.3.2. Recording of Magnetic Data

The magnetometer values were recorded twice.

a) Digital Recording in National Elliott-Code as figures of 5 digits in the order of 46 000γ - 49 000γ on punched tapes, simultaneously with the flight line coordinates of the Doppler navigator for their positioning. The punched tapes comprise the following data:

Magnetometer values , characterized by "+";

Fiducial marks, i.e. distance from the origin of the profile,given in hundredths of Doppler-miles, 4 digits, characterized by ".";

Cross-deviation from the medium positon of the profile, given in hundredths of Doppler-miles, 4 digits, characterized by "£".

b) Analog-Recording, on a Honeywell-ink-recorder with 200γ indication for the full scale of 250 mm (blue curve). This recording served only as a means for the control of the operation of the magnetometer. In addition, this instrument recorded the altitude above terrain and MSL (red and green lines, scale of height 1:20 000, 1 mm = 20 m). The measuring range of the ratio altimeter above terrain is limited to 1500 m.

3. Evaluation of Data and Presentation of Results

3.1. Profile Positioning

The location of some significant points of the flown lines was entered on the topographic maps 1:50 000 by means of the strip film of the aerial camera (film scale approx. 1:15 000). For the electronic evaluation of the survey, for each line the UTM-coordinates of these reference points were taken from the maps and manually punched on a tape. By comparing the UTM-coordinates of the reference points with their Doppler-recordings at the punched tape, the UTM-coordinates of all fiducials were determined with PRAKLA's National Elliott 803 computer (NE 803).

All northern, i.e. x-coordinates in the maps as well as in the regional field data are reduced by 3 000 km.

3.2. Processing of Magnetic Data

3.2.1. Elimination of the Diurnal Variation of the Magnetic Field

It is well known that records of the diurnal variation at a ground station are not always representative for a survey area which is situated up to 450 km off the recording station. Nevertheless, during all survey flights the variation of the total intensity was measured by a second magnetometer, in order to eliminate at least the short-periodic parts of the variation. This ground station was installed at the Kandahar International Airport which is approximately located in the center of the survey area.

The short periodic elements of the variation were determined for the moment of each fiducial recording by precise time comparison of ground station and aircraft records, then digitally interpolated and finally eliminated from the survey data.

The still existing long-periodic parts of the variation were eliminated in the course of the digital evaluation of data as follows:

Experience has proved that the long-periodic parts of the variation are of linear character within the short time of the survey of one profile and may be expressed by $a + bx$ (x = length on profile).

If an adjustment by the method of least squares is carried out with the total of contradictions w_{ij} of magnetometer data t_{ij} appearing at the profile intersections, the minimum condition $\Sigma w_{ij} \Rightarrow$ minimum with

$$w_{ij} = \left[t_i - (a_i + b_i \Delta x_i)\right]_M - \left[t_j - (c_j + d_j \Delta x_j)\right]_K$$

yields the coefficients a_i, b_i for survey profiles resp. c_j, d_j for control profiles, the parameters of the long-periodic terms of the variation.

Having corrected the total of values correspondingly, the residual contradictions at profile intersections are generally in the order of the noise level of the magnetometer, i.e. $\pm$ 1 γ. That means, applying this method eliminates the influence of the long-periodic variation completely. The remaining contradictions - if any - are then distributed in the vicinity of the profile intersections as it can be assumed that they are due to local errors in position or altitude.

3.2.2. Calculation of the Regional Field

Because the local anomalies are desired as final results of the surveys, it is necessary to subtract a regional field from the measured total field.

For the calculation of the regional field of each individual survey area, the magnetometer values at the line intersections free from the variation have been applied.

The regional field is expressed as a mathematical formula of first degree indicating an exactly defined value for each measured point.

,he formula reads:

$$T_0 = a_{00} + a_{10}\,\Delta x + a_{01}\,\Delta y$$

with

$\Delta x = x - x_0$, in 10^1 m; dimension of $a_{00} = [\gamma]$;
$\Delta y = y - y_0$, in 10^1 m; dimension of a_{10}, $a_{01} = [\gamma/10\ \text{m}]$;

x_0, y_0: coordinates of the origin of the regional field in the UTM-system in 10^1m.

The separate interpretation of the individual survey areas naturally resulted in slightly differing regional fields. Because of temperal reasons already mentioned under section 2.3.1, it was not possible to perform the last evaluation step (interpolaticn of the isanomalies) after having completed the calculation of all regional fields, and thus knowing a mean regional field for the construction of the isanomalies. The first maps had already been terminated when the last survey areas were still under survey. Additionally, the use of a mean regional field was contradicted by the fact that the total survey area is divided into 2-UTM zones, i.e. practically into two different geodetical coordinate systems.

The following linear regional fields have been applied:

Survey Area	UTM-Zone	Reference x_0 [10 m]	Point y_0 [10 m]	a_{00} [γ]	a_{10} [γ /10m]	a_{01} [γ/10m]
1	42	35 000	15 000	46 951.9	0.04300	0.01488
2	42	35 000	15 000	46 989.4	0.04200	0.01340
3	42	50 000	28 000	47 754.4	0.04200	0.01400
4	41	50 000	50 000	47 307.8	0.04258	0.01388
5	41	50 000	50 000	47 277.6	0.04237	0.01457
6	41	25 000	50 000	46 288	0.04220	0.01310
7	41	25 000	36 000	46 101	0.04290	0.01270
8	41	25 000	36 000	46 101	0.04290	0.01270
9	41	32 000	58 000	46 694.7	0.04290	0.01270
11	41	40 000	29 000	46 677	0.04290	0.01270
12	41	32 000	35 000	46 377	0.04190	0.01270
14	41	25 000	50 000	46 262	0.04380	0.01620

Related to the origin of all regional fields, 30° N, 60°E with the UTM coordinates mentioned in section 3.3.1

x_0 = 32 262 [10 m], y_0 = 78 942 [10 m] in zone 41

resp.

x_0 = 32 262 [10 m], y_0 = 21 058 [10 m] in zone 42

the following mean regional field

$$T_0 \ \gamma = 46\,960 + 0.0426 \cdot \Delta x + 0.0136 \cdot \Delta y$$

with Δx and Δx in [10 m]

differs only very slightly from each individual regional field, and may therefore be used for any future practical purposes.

The local anomalies - the difference between the surveyed field and the regional field - were represented in maps in form of "isanomalies of the total magnetic field".

3.2.3. Calculation of the Isanomalies of the Total Intensity

The anomalies of the total intensity are received by applying the following equation:

$$\Delta T = T_{measured} - \text{short periodic variation} - \text{long periodic variation} - T_{regional}$$

and represented in steps of $\pm n \cdot 5\gamma$ equidistance and of $\pm n \cdot 10\gamma$, resp, (n = integer).

As result, the electronic computer yields a list of the coordinates of the intersections of isanomalies and flight lines. Moreover, the drafting machine draws a map of these intersections (equidistance 5γ and 10γ, resp.). This map served as the basis for the manually performed construction of the isanomalies.

3.2.4. Data Processing Program of PRAKLA

The program system represented in illustration 1 is composed of 8 computing steps:

1st Computing Step

During the first computing step, the navigation and magnetometer tapes are checked for correct coding and punching errors. If one of the tapes contains errors they will be shown on the result tape of the first computing step and entered in a list.

2nd Computing Step

During the second computing step corrections are determined by means of the error list of computing step no. 1 and punched on a correction tape.

3rd Computing Step

The correction strip is checked and the data contained therein are added to the original measuring tape, which will produce perfect navigation and magnetometer tapes.

4th Computing Step

Based on the synchro-data, the navigation and magnetometer tapes are combined in a fourth step to form one tape containing both, coordinates and magnetometer data. The records of the base station have already been subtracted from the magnetometer values, i.e. the short variation has been eliminated. In the event of method D being applied, also the Doppler coordinates are converted into map coordinates.

5th Computing Step

Based on the position coordinates, the intersections of measuring and control profiles are determined during this step, and the magnetometer values for these points are determined.

6th Computing Step

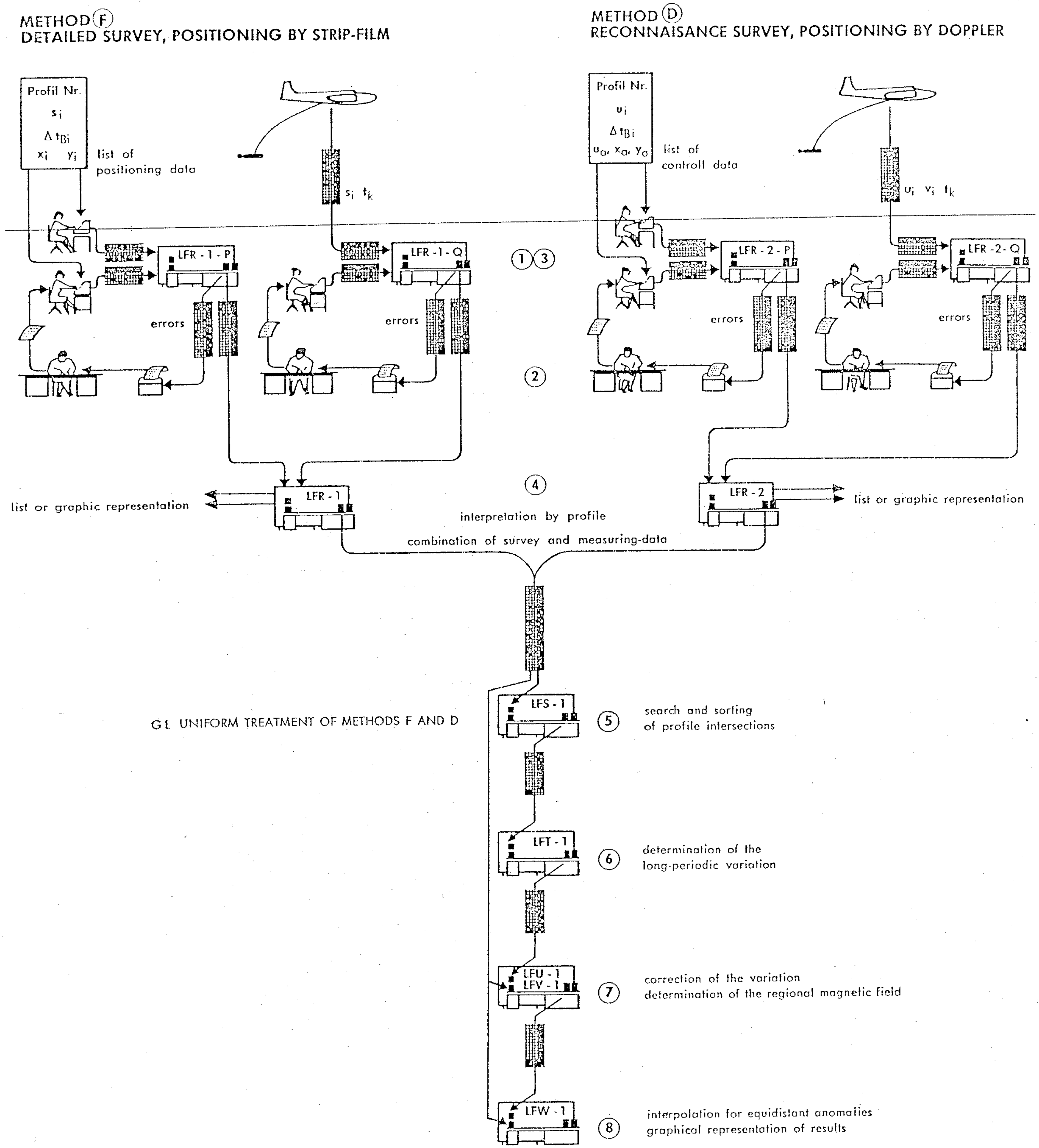
During this step the contradictions of the magnetometer values at the profile intersections are compensated. This compensation supplies the long periodic part of the variation of the magnetic field in form of a linear correction for every measuring and control profile. In addition, the deviations due to different flying heights are determined and eliminated. Further the corrected magnetometer values at the intersections are employed to determine the normal magnetic field of the area under survey which is applied in the form of a general quadratic function.

7th Computing Step

The magnetometer data reduced by the variation and the normal field are interpolated for equidistant anomalies and the position coordinates are made available at these points. The result of the complete interpretation is a list with coordinates and equidistant anomalies.

8th Computing Step

In accordance with the results of the 7th computing step, the isanomalies are either drawn by hand and connected or they are plotted by the automatic map-plotter CORADOMAT. In the latter case, the only work to be done by hand is the connection of corresponding anomalies.



ELECTRONIC INTERPRETATION OF AIRBORNE-MAGNETIC MEASUREMENTS

Illustration 1

Report Aeromagnetic Afghanistan

PRAKLA – Hannover 066 133

~~3.3. Presentation of Results~~

3.3.1. Compilation Maps of the Isanomalies of the Total Magnetic Field, Scale 1:1 000 000

For facility of reviewing the whole results of the Afghanistan surveys, the isanomalies including the topography were reduced to the scale 1:1 000 000, and were represented in two maps in form of two-colour prints (encl. 3: Western Part, encl. 4: Eastern Part).

The equidistance of the isanomalies in the survey areas 1 to 5 and 14 is 5 γ, in the remaining parts 10 γ.
The seperating line of the two maps is the meridian 66° being at the same time the boundary line between the 41st and 42nd zone of the UTM-coordinate-system.

Point 30°N, 66°E was chosen the reference point of the mean regional field. The UTM-coordinates of the reference point and the coefficients of the mean regional field are indicated in the legend of the enclosures 3 and 4.

3.3.2. Compilation Maps of the Isanomalies of the Total Magnetic Field, Scale 1:500 000

The maps of the isanomalies have been prepared as two-colour prints and have also been reduced to the scale 1:500 000, in order to facilitate their comparison with the geological maps of southern Afghanistan.

The total survey area was represented in 6 maps (encl. 5 to 10). The size of the maps is between 2° and 3° in N-S direction, and between 3° and 3.5° in E-W direction.

~~The survey areas are represented in the individual~~ maps as follows:

Enclosure 5:	Survey area	7, south-western part
	" "	12, central and southern part
	" "	14, northern part
Enclosure 6:	Survey area	7, central and northern part
	" "	8
	" "	11
	" "	12, northern part
Enclosure 7:	Survey area	6
	" "	7, south-eastern part
	" "	9, southern part
Enclosure 8:	Survey area	1, central and western part
	" "	4, central and southern part
	" "	9, central and northern part
Enclosure 9:	Survey area	4, northern part
	" "	5
Enclosure 10:	Survey area	1, eastern part
	" "	2
	" "	3

In the area of the meridian 66° (boundary meridian of the UTM-systems) it was not to be avoided to represent parts of survey areas in the adjacent UTM-system. Therefore the UTM-system 41 in the enclosure 8 and 9 was extended up to the meridian 67°.

3.3.3. Maps of the Isanomalies of the Total Magnetic Field, Scale 1:200 000

The whole reconnaissance survey covers 34 maps of the isanomalies in the scale 1:200 000 (encl. 11-44). The sheet layout is given in enclosure 2. (2-46) The maps have a size of 1° in longitude and 1° in latitude, with the exception of the enclosures 11, 12 and 16 which are slightly more extended.

The maps of the isanomalies of the total magnetic field were prepared as two-colour prints, automatically preconstructed by PRAKLA'S plotter CORADOMAT with an accuracy of ± 0.07 mm on 0.15 mm transparent film Pokalon of stable size.

They contain:

The isanomalies of the total magnetic field with an equidistance of 5γ or 10γ, resp., each fifth stronger, the intersections with the flight lines being automatically plotted, lines of equal anomalies being drawn by hand, brown colour;
a simplified representation of the topography, black colour, the automatically drawn location of the flight lines with fiducial marks, each fifth numbered, black colour;

the subtracted regional field in parameter-representation in the legend.

In the northern and eastern part of the survey area (regions 1 - 5) the equidistance of the contour lines is 5γ. In the western and southern part (regions 6 - 9, 11, 12) due to the steeper gradients the equidistance is 10γ.

~~In addition to the reconnaissance program, enclosure~~ 21 shows a compilation of the northern part of the detail area 14, drawn in the same manner as described above.

3.3.4. Maps of the Isanomalies of the Total Magnetic Field, Scale 1:50 000

The detail survey in area 14 covers 8 maps of the scale 1:50 000 (encl. 45 - 52). The maps are numbered from northwest to southeast and have a size of 18' in latitude and 20' in longitude.

The maps are drawn in the same manner as described in section 3.3.3. The equidistance of the isanomalies is $5\,\gamma$.

After the construction of the isanomalies it was evident that for the northern and central part of this region the chosen scale was relatively large, and a scale of 1:200 000 would have been quite sufficient for the exact drawing of the contour lines; for the southern part the scale 1:50 000, however, was the more suitable one.

3.3.5. Selection of Data for Interpretation (Harmonic Analysis)

In cooperation with the Bundesanstalt für Bodenforschung 7 areas being suited for the interpretation by means of the harmonic analysis were selected (encl. 53 and 54, scale 1:1 000 000). For these areas, the values of the anomalies situated on a square grid were read from the

~~maps of the isanomalies without smoothing,~~ were put down in lists, and stamped on punched cards. The punched data begin with the extreme south-western value of the extreme southern (lowest) line, and end with the extreme north-eastern value of the extreme northern (highest) line, resp., and they are sequentially arranged in series.

<u>1st Area under Interpretation</u>

SW-point: x = 45 730, y = 31 120; [10 m]
NW-point: x = 52 460, y = 30 600;
NE-point: x = 52 980, y = 37 330;

Lines: 28; Columns: 28; Total number of values: 784;
Magnetic azimuth of the direction of columns: $-7{,}5^{\circ}$;
Grid width 2.5 km.

This area comprises the undisturbed south-eastern part of the survey area 1.

<u>2nd Area under Interpretation</u>

S-point: x = 43 776; y = 39 545; [10 m]
W-point: x = 55 531, y = 31 490;
N-point: x = 66 695, y = 47 782;

Lines: 59; Columns: 80; Total number of values: 4720;
Magnetic azimuth of the direction of columns: $-37{,}5^{\circ}$;
Grid width 2.5 km.

The second area under interpretation coincides mainly with the survey area 2.

~~3rd Area under Interpretation~~

W-point: x = _ , y = 45 900; [10 m]
N-point: x = 72 956, y = 51 019;
E-point: x = 69 446, y = 55 885;

Lines: 36; Columns: 25; Total number of values: 900;
Magnetic azimuth of the direction of columns: +34°;
Grid width 2.5 km.

This small region is situated in the western part of the survey area 3.

4th Area under Interpretation

S-point: x = 58 000, y = 69 100; [10 m]
W-point: x = 73 470, y = 58 069;
N-point: x = 79 276, y = 66 211;

Lines: 77; Columns: 41; Total number of values: 3157;
Magnetic azimuth of the direction of columns: -37°;
Grid width 2.5 km.

This area under interpretation comprises the survey areas 4 and 5, with the exception of the anomalies in the northern and southern part.

5th Area under Interpretation

S-point: x = 26 233, y = 59 757; [10 m]
W-point: x = 38 821, y = 50 542;
N-point: x = 53 707, y = 70 876;

Lines: 40; Columns: 64; Total number of values: 560;
Magnetic azimuth of the direction of columns: -38°;
Grid width 4 km.

This area under interpretation comprises the south-eastern part of the survey area 7, the survey area 9, and the northern parts of the survey areas 14 and 6.

~~6th Area under Interpretation~~

S-point: x = 31 750, y = 46 300; [10 m]
W-point: x = 48 211, y = 34 250;
N-point: x = 60 261, y = 50 711;

Lines: 52; Columns: 52; Total number of values: 2704;
Magnetic azimuth of the direction of columns: -38°;
Grid width 4 km.

This area comprises the survey areas 7 and 12, and the southern parts of the survey areas 8 and 11.

7th Area under Interpretation

SW-point: x = 61 500, y = 40 700; [10 m]
NW-point: x = 66 744, y = 40 940;
NE-point: x = 66 504, y = 46 184;

Lines: 22; Columns: 22; Total number of values: 484;
Magnetic azimuth of the direction of columns: 0°;
Grid width 2.5 km.

This area is situated in the relatively undisturbed northern part of the survey area 8.

The average value of the magnetic inclination of South Afghanistan is 48°.

4. Results

The general shape of the anomalies of the total magnetic field is to be described the easiest by means of the maps in the scale 1:1 000 000 (encl. 3 and 4).

4.1. Eastern Part of the Survey

The shape of the anomalies in the eastern part of the survey area (encl. 4) is characterized by three disturbed zones which are distinctly separated from each other. These zones are striking from SW-NE to SSW-NNE, and are separated by relatively undisturbed regions from each other.

The first of these characteristically disturbed zones is situated in the northern top part of the survey area 1. Apparently, this zone is the southern prolongation of a more extended area with strong anomalies. More southward we find the most intensely disturbed area which is separated by a less disturbed zone. Because of the fact that the anomalies are situated very close together in this region, it has not always been possible to clearly determine the correlating maxima and minima. The amplitudes reach values up to almost 500 γ- and even exceed this intensity - i.e.:

+305 γ/ -225 γ ; +465 γ/ -5 γ ; +225 γ / -245 γ ;

Generally, however, they are lower.

One spur of this disturbed zone strikes in a north-eastern direction toward the survey area 2 (southward the road of Kalat-i-Ghilzal-Mukur). The sharply developed south-eastern boundary line of this zone of anomalies is indicative of a tectonical fault.

Toward the SE, an undisturbed region formed by the south-eastern part of the survey area 1, the main part of the survey area 2, and the western part of the survey area 3 follows. Here are large extended structures with smooth contours: one broad maximum between Zarghun Shar and Fagiras Quala, a minimum in the north-western part. the complete shape of which is probably impaired by the above mentioned spur, and a further large extended minimum south of Shinkai and Kanakah at the boundary between the survey areas 1 and 2.

More eastward - in the south of the line connecting Rustan-Wazi-Khwa and Quala-i-Babakar - no large extended structures are to be recognized. The isanomalies in this area are characterized by rather narrow and long structures with only small amplitudes mainly striking in the direction SW-NE. These structures seem to be dependent on the topographic relief.

In the eastern part of the large extended maximum Zarghun Shar - Fagiras Quala a broad minimum reaches from the region Urgun up to almost Gardez. It is followed in the eastern and north-eastern part by strongly disturbed regions. In the south-west of Almarah we find the strongest anomly of the eastern part of the survey area with +1115 γ and -225 γ .

4.2. Western Part of the Survey

4.2.1. Survey Areas 4 and 5

The south-eastern part of the survey area is characterized by a greater number of relatively narrow spaced anomalies the intensity of which mainly ranges between +260γ and -260γ (encl. 3).

Further to the north-west, the central part of the survey area 4 which strikes in a SW-NE direction follows. This is a very calm zone with low gradients being limited in the NW by a small chain of anomalies.

The isanomalies in the survey area 5 run rather regularly - with the exception of some individual narrow anomalies. Only in the utmost northern part strong anomalies occur, the preferred direction of strike being E-W.

4.2.2. Survey Areas 6 to 14

The character of the survey areas 6 to 9, 11, 12 and 14 situated in the south-western part of the area under survey, is entirely different from that of the survey areas 1 to 5. The anomalies have - apart from several exceptions - somewhat smaller amplitudes than in the region. eastward Kandahar, and are of essentially more homogeneous and rounder shape. Mainly, some maxima or minima are arranged in groups, resulting in larger regions with a higher or lower level, respectively. The maximum in the northern part of the survey areas 6 and 14 striking over approximately 100 km, and the extended minimum in the central part of the survey area 6 are especially characteristic.

The southern part of the survey areas 6 and 14, however, is very strongly disturbed and of irregular character (area 14 being represented only in the maps of the scale 1:50 000). Narrow spaced anomalies with high amplitudes are here situated close together. This fact is indicative of the occurence of magnetic rocks at the surface (basalts).

The isanomalies in the northern part of the survey areas 7 and 12, as well as in the survey areas 8 and 11 are somewhat more disturbed than in the central region of the western part of the total survey area being represented in enclosure 3. The individual anomalies are here more clearly separated from each other. At the boundary between the areas 11 and 12 - close to the Iranian frontier and near Chakansur - the anomaly with the largest amplitude of the total survey area is encountered (+540γ/-920γ).

More toward the north, zones being more or less disturbed are alternating; stronger anomalies are found in the area north-west of the line connecting Juwain and Farah. The region between Anarda and Daulatabad is relatively calm.

5. Summary

On behalf of the Bundesanstalt für Bodenforschung PRAKLA carried out aeromagnetic surveys in large southern and south-eastern parts of the Kingdom of Afghanistan. The aim of these surveys was to gain a more detailed picture of the geological structure. By means of maps of the total magnetic field the individual geological regions may be clearly recognized. It was possible to discover structures being not - or not yet precisely - known up to now.

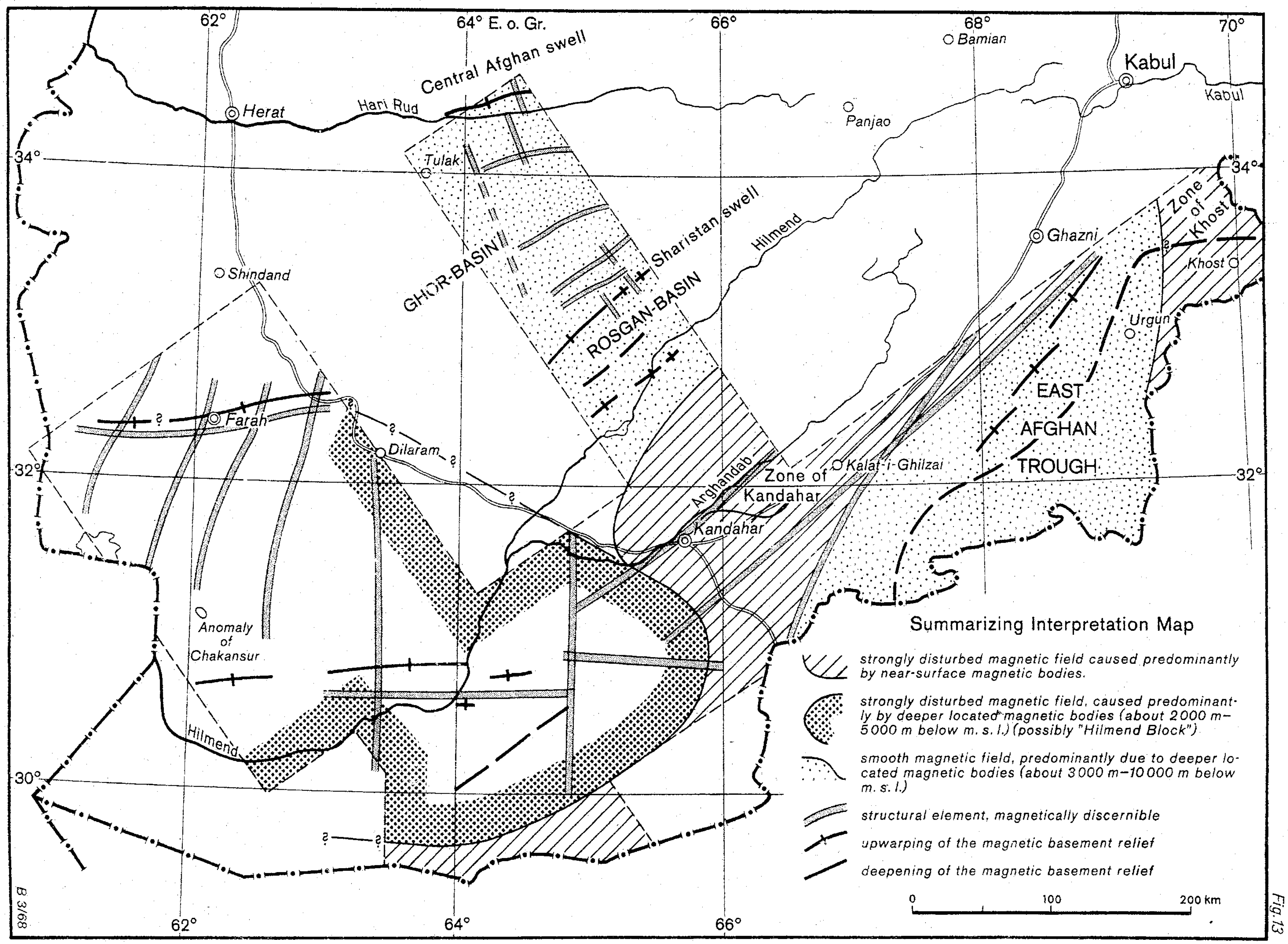
A geological interpretation of the results of the aeromagnetic surveys was not provided for in the agreement. This interpretation will be executed by the Bundesanstalt für Bodenforschung.

Hannover, June 15, 1967

P R A K L A
GESELLSCHAFT FÜR PRAKTISCHE
LAGERSTÄTTENFORSCHUNG GMBH

Dr. Zettel   i. A. Boie

(Dr. W. Zettel)   (Dipl.-Ing.D. Boie)



Aeromagnetic survey Afghanistan 1968

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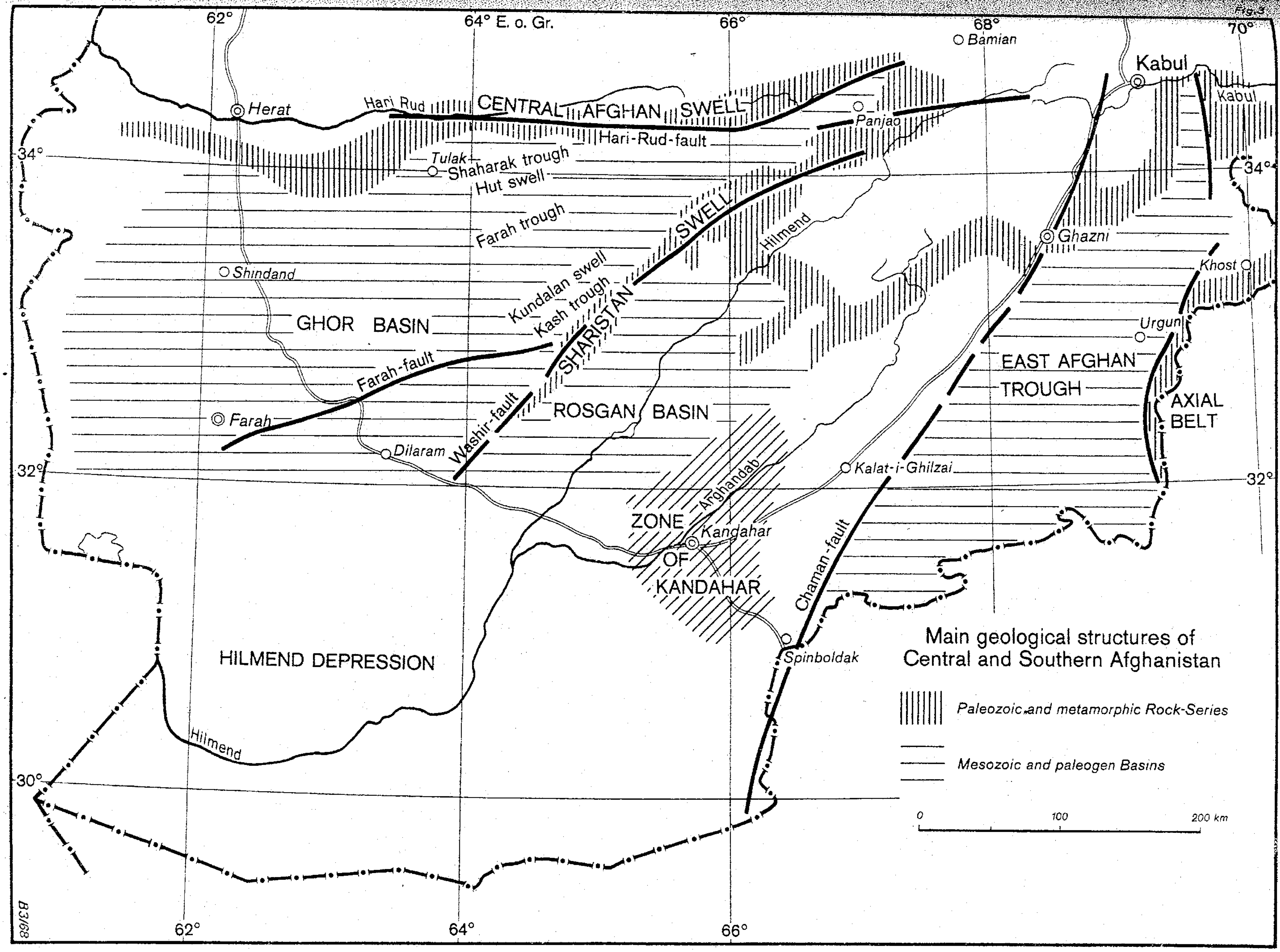

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