PUBLICATION OF THE NETHERLANDS GEODETIC COMMISSION

GEODETIC WORK

IN

THE NETHERLANDS

1975-1978

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Canberra, 1979

1979

RIJKSCOMMISSIE VOOR GEODESIE; THIJSSEWEG 11, DELFT, THE NETHERLANDS

I CONTROL SURVEYS

1.1 Primary triangulation

Distance and angle measurements were carried out to check the coordinates of the primary station Monnickendam. Between the primary stations Westerland and Naarden the traverse Westerland-Nieuwe Niedorp-Monnickendam-Naarden was measured. At Westerland the directions to Eierland, Workum, Enkhuizen en Nieuwe Niedorp were observed. Eierland, Workum and Enkhuizen are stations of the primary network. The direction to Workum was very difficult to observe and the results had to be rejected. To strengthen the traverse the direction to Enkhuizen was measured at Nieuwe Niedorp and Monnickendam. At Naarden the directions to Mijdrecht, Monnickendam and Harderwijk were measured. The distances in the traverse were measured with a tellurometer MRA 4 and the observations were spread over at least three days at every station.
The adjusted coordinates of Monnickendam, computed from the new measurements, differed only 0.05 m and 0.02 m from the original coordinates. Statistically only differences of 0.15 m and 0.13 m are significant (with $\alpha = 0.01$ and $\beta = 0.80$) so the original coordinates were maintained.

1.2 Coordinates of the Satellite Observatory Kootwijk

The camera-axes at Kootwijk have been connected to the primary stations Veluwe, Rhenen and Amersfoort by distance and angle measurements. To achieve this it was necessary to include the auxiliary stations water-tower Kootwijk and radio-beacon Nieuw Milligen in the network. The distances were measured with a tellurometer MRA 4 and the angles with a theodolite Wild T3.

1.3 Electromagnetic distance measurement

In 1977 the "International Symposium on Electromagnetic Distance Measurement and the Influence of Atmospheric Refraction" was held at Wageningen. It was sponsored by IAG Special Study Group 1.42 and hosted by the Netherlands Geodetic Commission and the Agricultural University at Wageningen. The proceedings were published in 1977 by the Netherlands Geodetic Commission.

1.4 Levelling

1.4.1 *General*

The measurements for the Fourth Precise Levelling of the Netherlands have been completed. The network consists of 66 circuits., 330 nodal points and 395 sections, with a total length of 5590 km. The network has been measured partly hydrostatically partly optically.
The adjustment of the levelling net has not been completed yet.

1.4.2 *Hydrostatic levelling*

Hydrostatic levelling has been carried out by the specially equipped ship mentioned in previous reports. In 1975 the old ship has been replaced by a new one, called NIVEAU (= level) again. The length of the NIVEAU is 26.30 m, the width 5.00 m and the draught 1.30 m, so the ship can be used in shallow water.

1.4.3 *Instruments*

For first order levelling the automatic instruments Zeiss Ni-2 and Jena Koni 007 were used.

1.4.4 *Methods*

The methods employed are the same as those described in the reports presented in Toronto (1957) and Helsinki (1960).

1.4.5 *Datum of the network*

The datum of the network is Normaal Amsterdams Peil (N.A.P.), fixed by an underground benchmark at Amsterdam.

1.4.6 *North West European Lowlands Levelling*

The heights of the benchmarks, in the NWELL-system, have been published in 1975.

1.4.7 *Réseau Européen Unifié de Nivellement*

The Dutch contribution to the REUN consists of two circuits, a connection with the tide gauge at Den Helder, and five links with the German and Belgian nets, with a total length of 1310 km. The measurements have been transformed to geopotential units. The adjustment of the REUN will take place in 1979.

1.4.8 *Special measurements*

In 1975 efforts have been made to level hydrostatically from the Dutch coast to a gas production platform in the North Sea, using a pipeline with a length of 177 km and a diameter of some 90 cm. The heigth difference of both ends of the pipeline led to the use of a large mercury manometer attached to the low end of the pipe. In addition to the above mentioned measurements, readings of precise pressure gauges (deadweight testers) at a pressure of 40 atmospheres were used. This experiment was more or less a success.
In 1976 another pipeline (with a length of 120 km) could be used for experiments with deadweight testers.
The system showed that it could be used in future work, but a number of practical problems still remain to be solved.

1.5 Geodetic astronomy

1.5.1 *Laplace stations*

The six Laplace stations of the Dutch national network and their misclosures were published in 1975. Two new Laplace stations (Oss and Luiksgestel, 1975) were measured for connecting the international high precision traverse Malvern-Graz to the satellite observatory at Kootwijk.

1.5.2 *Deflection of the vertical*

In the period 1974-1977 astronomical latitude and longitude were determined at 25 stations of the national network using a Zeiss Ni2 Astrolable. The results of these observations and the deviations of the vertical with respect to ED50 datum were published in 1978.

1.6 Marine-geodetic activities of the Hydrographic Service of the Royal Netherlands Navy

1.6.1 *The Netherlands*

Hydrographic surveys were carried out in the southern part of the North Sea and in coastal areas. In the North Sea the use of the two Hi Fix/3 Rijnmond chains for horizontal control was continued until March 1976 after which the newly developed Hi Fix/6 Rijnmond chain came into operation. In coastal areas the available primary and secondary trig points have been used whereas occasionally surveys were carried out using local HiFix chains, operated by the Department of Public Works.

1.6.2 *Continental Shelf Activities*

In 1978 an inventory has been started of trilateration and triangulation data used for positioning on the Netherlands' part of the continental shelf of the North Sea. Preliminary actions and orientations are going on for the establishment of a geodetic basis in the southern part of the North Sea.

1.6.3 *General*

The automation of oceanographic and hydrographic data logging and processing is fully operational. The oceanographic vessel H. Nl. Ms. Tydeman is serving as a platform for scientific research by several universities and institutions in the Netherlands.

1.7 Publications

1.7.1 *Levelling*

WAALEWIJN, A. — Honderd jaar nauwkeurigheidswaterpassing. Nederlands Geodetisch Tijdschrift, Delft, 1975, No. 6, pp. 126-130 — In Dutch

DAMME J.H. TEN — Tien jaar primair hydrostatisch waterpassen. Geodesia, Delft 1975, No. 9, pp. 213-217 — In Dutch

HEIGHT of benchmarks in The Netherlands in the NWELL-system. Netherlands Geodetic Commission, Delft 1975.

WAALEWIJN, A. — Hydrostatic levelling in the southern North Sea. The Hydrographic Journal, 1977, No. 2, pp. 3-10.

1.7.2 *Geodetic astronomy*

HUSTI, G.J. — Geodetic-astronomical observations in The Netherlands, 1947-1973. Netherlands Geodetic Comission, Publ. on Geodesy, New Series, Vol. 6, No. 1, Delft, 1975.

HAASBROEK, N.D. — Prof. F. Kaiser en S.H. de Lange in hun relatie tot de astronomische plaatsbepaling van omstreeks 1850 in het voormalige Ned. Indië. Netherlands Geodetic Commission, 1977 — In Dutch.

HUSTI, G.J. — A method of determining latitude and azimuth simultaneously by star altitudes. Survey Review, No. 184, April 1977, pp. 66-70.
HUSTI, G.J. — Deviations of the vertical in The Netherlands from geodetic-astronomical observations. Netherlands Geodetic Commission, Publ. on Geodesy, New Series, Vol. 6, No. 3, Delft, 1978.

1.7.3 *Marine geodesy*

MUNCK, J.C. DE — Het gebruik van de collocatie-methode van Mortiz (1972) voor de vereffening van de calibratie van een systeem voor de radioplaatsbepaling. Nederlands Geodetisch Tijdschrift, Delft, 1975, No. 3, pp. 45-48 — In Dutch.
WAL, J.H.M. VAN DER — De plaatsbepaling van R.W.S.-metingen op de Noordzee. Nederlands Geodetisch Tijdschrift, Delft, 1975, No. 8 pp. 151-158 — In Dutch.
MUNCK, J.C. DE — Systemen van plaatsbepaling op zee. Nederlands Geodetisch Tijdschrift, Delft, 1976, No. 4, pp. 65-69 — In Dutch.
STELLINGWERFF BEINTEMA, S. — The use of radiofrequencies for electronic positioning systems and the application in Sercel's Syledis. Proceedings of the International Symposium on Electromagnetic Distance Measurement and the Influence of Atmospheric Refraction, Wageningen, 1977, pp. 193-202.
MUNCK, J.C. DE, H.M. DE HEUS and W. TUITMAN — Applying the movement smoothness of a vehicle to determine the position of transponders. Proceedings of the International Symposium on Electromagnetic Distance Measurement and the Influence of Atmospheric Refraction, Wageningen, 1977, pp. 290-301.

1.7.4 Refraction

RICHARDUS, P. — An experiment with a high precision method of aligment. Proceedings of the International Symposium on Electromagnetic Distance Measurement and the Influence of Atmospheric Refraction, Wageningen, 1977, pp. 323-327.

2 SPACE TECHNIQUES

2.1 Working Group for Satellite Geodesy

Operating under the auspicies of the Netherlands Committee for Geophysics and Space Research, the Working Group annually reports to COSPAR.

Photographic observations of station-to-satellite directions gradually ceased. From the middle of 1976 onwards laser ranging has been the primary type of satellite observations from the Delft University of Technology's Observatory for Satellite Geodesy at Kootwijk. The laser site has identification number 7833. The main instrument features are:
— pulsed ruby laser;
— transmitted pulse width: 4 ns;
— maximum pulse output: 3 J;
— night and daylight capability on near-earth satellites;
— current r.m.s. single shot ranging precision: 20 cm;
— maximum repetition rate: 15 ppm.
Upgrading of the equipment to better precision will be effected in 1979 and thereafter.

Satellites ranged were: Beacon Explorer (1965-32A), Geos-1 (1965-89A), Geos-2 (1968-02A), Starlette (1975-10A), Geos-3 (1975-27A), Lageos (1976-39A) and Seasat-1 (1978-64A). These observations were made either on a routine basis or as contributions to dedicated scientific programmes. Such programmes were the first European Range Observations to Satellites (EROS) campaign (August 1 - November 30, 1977) and the Seasat-1 mission. The latter contribution was part of the involvement of the EROS organisation in the Seasat Users Research Group of Europe (SURGE) programme as ESA proposed to NASA. Within the EROS-framework the Working Group was charged with several tasks of an organizational nature.

Laser data editing and pre-processing was performed at the Kootwijk observatory. Theoretical and applications-oriented research on space techniques was continued, the emphasis being transferred, however, to orbital approaches. A collaboration with the Section Orbital Mechanics of the Delft University's Department of Aerospace Engineering proved quite fruitful.

2.2 Doppler positioning

In collaboration with the Netherlands Triangulation Service and with the Department of Surveying and Photogrammetry of the Agricultural University at Wageningen, the Department of Geodesy at the Delft University of Technology took part in several Doppler surveys in Europe, e.g.: the second European Doppler Observation Campaign EDOC-2 (April 23 - May 7, 1977) the German-Austrian Doppler Observation Campaign of early summer 1977, the EROS Doppler Observation Campaign (December 2 - December 16, 1977) and the Doppler-positioning of European Seasat-1 tracking stations (June 23 - July 4, 1978). A Dutch team took part in the Pamir-Himalaya Geophysical Project Seismic Deep Sounding expedition of September 1978 and doppler-positioned several sites in the area.

2.3 Publications

AARDOOM, L., D.L.F. VAN LOON, T.J. POELSTRA — The astrometric procedure of satellite plate reduction as applied at the Delft Geodetic Institute. A description with some results for WEST, NGSP and ISAGEX, Netherlands Geodetic Commission, Publ. on Geodesy, New Series, Vol. 5, No. 4,1975.

AARDOOM, L. — Satellite geodesy applied to geodynamics. In: Progress in Geodynamics, North Holland Publ. Co. Amsterdam, 1975, pp. 36-44.

AARDOOM, L. — On the interrelation of classical and space geodetic systems of position reference. In: On reference coordinate systems for earth dynamics, proceedings IAU colloquium No. 26, Torún, (Poland), August 26-31, 1974, pp. 445-452 (1975).

AARDOOM, L. — Beweging in de geodesie. In: Lustrumboek Landmeetkundig Gezelschap "Snellius" 1970-1975, pp. 171-182, Delft, 1975 — In Dutch.

BACKER, A and F.W. ZEEMAN, with W.H. HAVENS and H. VISSER — The satellite ranging station at Kootwijk (Holland) In: Laser tracking instrumentation. Proc. Second Workshop, Praag, August 11-16, 1975.

ZEEMAN, F.W. with W.H. HAVENS and H. VISSER — A design description of the satellite ranging station at Kootwijk. Acta Astronautica Vol. 2, pp. 891-895, 1975.

AARDOOM, L. — Observatorium voor Satellietgeodesie. In: Ruimtevaart in Nederland, jubileumnummer Ruimtevaart in Nederland, December 1976, pp. 71-77 — In Dutch.

LOON, D.L.F. VAN, T.J. POELSTRA — The modified astrometric procedure of satellite plate reductions as applied at the Kootwijk Observatory of the Delft Geodetic Institute, a description with some results for SAOP. Netherlands Geodetic Commission Publ. on Geodesy, New Series, Vol. 6, No. 2, 1976.

ZEEMAN, F.W. with H. VISSER and W. WERNER — Meting van de afstand tot satellieten met laserpulsen. Ned. Tijdschr. voor Natuurkunde, Jaargang 42, No. 12, 1976, pp. 155-156 — In Dutch.

WAKKER, K.F., B.A.C. AMBROSIUS, H.J.D. PIERSMA — Computational results of the NISLAP and AIMLASER programs for satellite position predictions. Delft University of Technology, Dept. of Aerospace Engineering, Report VTH - 212, 1976.

AMBROSIUS, B.A.C., H.J.D. PIERSMA, K.F. WAKKER — Description of the AIMLASER satellite orbit prediction program and its implementation on the Delft University IBM Computer. Delft University of Technology, Dept. of Aerospace Engineering, Report LR-218., 1976.

AARDOOM, L. — Ruimtegeodesie, Natuur en Techniek, 45 No. 11, pp. 796-812, 1977 — In Dutch.

POELSTRA, T.J., F.W. ZEEMAN — Activiteiten op het Observatorium voor Satellietgeodesie te Kootwijk, Zenith, 4, No. 2, pp. 47-49, 1977 — In Dutch.

ZEEMAN, F.W. — A laser system for ranging to satellites. Proceedings International Symposium on Electromagnetic Distance Measurement and the Influence of Atmospheric Refraction. Wageningen, 1977, pp. 92-100.

AARDOOM, L. with K. RINNER — Applied Geodesy Panel-Chairman's report. Proceedings of the European Workshop on Space Oceanography, Navigation and Geodynamics, ESA SP 137, pp. 81-84, 1978.

AARDOOM, L. — On potential use of space techniques for applied geodesy. Proceedings of the European Workshop on Space Oceanography, Navigation and Geodynamics, ESA SP-137, pp. 81-84, 1978.

ZEEMAN, F.W. E. VERMAAT — Methode en toepassing van laserafstandmetingen in de satellietgeodesie. Ned. Geod. Tijdschr. 8, No. 2, pp. 23-29, 1978 — In Dutch.

3 GRAVIMETRY

3.1 The Netherlands

3.1.1 *Netherlands Gravity Base Net*

In 1975 the gravity base net was remeasured with two LaCoste-Romberg gravimeters and one Worden gravimeter. At 25 stations equally distributed over the country gravity was measured with a r.m.s. precision of 0.15 μ ms^{-2} (= 15μ gal). The measurements were connected with the International Gravity Standardization Net 1971 (IGSN-71) at the stations Amsterdam 21625L and Hannover 21629A. The results are given in the table below.

Primary gravity stations, 1975

Station	Lat.	Long.	Height (metre)	Normal gravity	g (mgal)	Δg (mgal)
Amsterdam 21625L	52°18'36"	4°45'57"	— 3.00	981.274.82	981.273.44	— 1.38
Arnhem	52°01'12"	5°55'42"	56.25	231.07	232.53	+ 1.46
Bergen (L)	51°36'05"	6°02'30"	13.40	207.43	202.46	— 4.97
Breda (-Bavel)	51°33'59"	4°49'48"	6.60	206.44	199.86	— 6.58
Delft A (Aula)	52°00'11"	4°22'25"	— 1.69	247.47	242.88	— 4.59
Delft G (Geodesie)	51°59'11"	4°23'19"	— 0.50	245.63	240.87	— 4.76
Eijsden	50°46'05"	5°43'35"	63.27	118.30	116.39	— 1.91
Eindhoven	51°28'03"	5°27'08"	18.09	194.17	168.17	— 26.00
Geulle	50°55'45"	5°45'32"	106.95	119.12	122.88	+ 3.76
Groningen	53°12'20"	6°34'18"	2.29	351.38	330.31	— 21.07
Heerenveen	52°57'44"	5°55'15"	1.00	330.60	332.42	+ 1.82
Leeuwarden	53°11'17"	5°47'51"	0,76	350.33	336.55	— 13.78
Lochem	52°09'45"	6°24'57"	14.26	256.55	267.37	+ 10.82
Malden	51°46'59"	5°51'31"	11.43	224.05	217.32	— 6.73
Meppel	52°42'35"	6°12'43"	1.63	308.37	307.97	— 0.40
Nijverdal	52°22'01"	6°26'56"	9.83	275.85	278.45	+ 2.60
Oirschot	51°30'13"	5°18'25"	16.65	197.80	174.55	— 23.25
De Poppe	52°18'26"	7°02'20"	32.10	263.74	275.40	+ 11.66
Reuver	51°17'25"	6°05'19"	24.90	176.41	175.44	— 0.97
Ubachsberg	50°51'13"	5°56'52"	185.69	088.12	096.39	+ 8.27
Utrecht	52°04'55"	5°05'13"	2.01	253.25	251.71	— 1.54
Vaassen	52°17'30"	5°58'49"	11.47	268.75	271.93	+ 3.18
Vlissingen	51°26'45"	3°35'42"	3.70	196.70	199.20	+ 2.50
Zestienhoven	51°57'07"	4°25'54"	1.34	242.03	237.81	— 4.22
Zurich	53°06'45"	5°23'32"	1.33	343.58	330.23	— 13.35

3.1.2 *North West European Lowland Levelling*

In order to control vertical movements of the earth's crust in northwest Europe a high precision gravity network is measured by University of Hannover under supervision of Prof. W. TORGE. In The Netherlands 4 base stations were measured: i.e. Heerenveen, Haarlem, Loenen and Gilze, each with two excentric stations.

The Delft University of Technology contributed in this project by some theoretical studies about the relations between gravity change, height change and movements of the earth's crust.

3.1.3 *Changes in gravity in the Groninger gasfield*

Accurate gravity measurements were carried out in 1978 at 21 stations situated on the Groninger gasfield. In future these measurements will be repeated in order to obtain information about the surface subsidence and changes in gravity as a result of the gas production.

3.1.4 *Changes in gravity in the mining area in South Limburg*

After closing down the collieries in this area the water-table rose alarmingly. To check the rise of the water table a dense and precise gravity network was established. In conjunction with control drillings this gravity network gives an indication of the changes of the water-level.

3.2 Surinam

In the southern part of Surinam a gravity network was measured with assistence of the Delft University of Technology. In the same area a satellite Doppler network was measured for positioning purposes.

3.3 Gravity at sea

3.3.1 *Atlantic Ocean*

In 1977 the Askania sea gravimeter of the Delft University of Technology was modernized at the Bodensee Werke. In 1977 and 1978 it was used by the Vening Meinesz Laboratory for measurements across the Mid-Atlantic Ridge. The results obtained were satisfactory and a detailed gravity map of the area, 12°-15°. N. Lat. and 44°-46° W. Long, was produced.

3.3.2 *North Sea*

In 1979 the Netherlands Geodetic Commission plans to make a detailed gravity survey over the Dutch part of the North Sea. This project is initiated by the Users Research Group of Europe (SURGE) of SEASAT. The North Sea was indicated as a test area for SEASAT. Although the SEASAT-I mission failed, the gravity survey will nevertheless be carried out.

3.4 Publications

(1) STRANG VAN HEES G.L. — Zur zeitlichen Aenderung von Schwere und Höhe. Zeitschrift für Vermessungswesen, 1977, No. pp.
(2) STRANG VAN HESS G.L. — Geodetische toepassingen van zwaartekrachtmetingen op zee (Internal report) — In Dutch
(3) STRANG VAN HEES G.L. — Over secular variations of gravity and height. Symposium: Secular variations of gravity Triest, 1977.

4 THEORY AND EVALUATION

4.1 Computing Centre, Geodetic Institute, Delft University of Technology

Since the Grenoble General Assembly progress has been made with summarizing measures for the reliability of networks. The λ-quantities, proposed in the Moscow report (1971), were thoroughly studied by H.M. DE HEUS, both from a theoretical and practical point of view. A publication on this subject is in preparation. Elaborated were the interrelation between measures for the reliability and measures for the precision of networks. Furthermore it was tried to establish a link with precision theories developed by other authors. A summary is given in [BAARDA, 1976a, 1976b, 1977].
J. VAN MIERLO studied in connection with deformation measurements possible links and/or similarities between the theory of S-transformations developed in Delft and various theories developed in other countries that make in one form or the other use of the theory of generalized inverse matrices. This research will no doubt clarify a comparative study in the field of deformation measurements. Now that he has changed his position in Delft for a professorate of the Technical University Karlsruhe at the time of preparing this report, it might be expected that good progress will be made in this field of research.
In the period covered by this report much attention has been paid to methods for the connection of geodetic networks of different type. To this end existing methods are being complemented or revised. Almost completed are a computational method for spatial terrestrial networks elaborated by H. QUEE and a study of M. MOLENAAR about the use of S-transformations and criterion matrices in photogrammetry, both using the quaternion theory. A start has been made with the analysis of VLBI- and satellite-type networks. Completed is a study about the connection between geometric and gravimetric theory. Several aspects of the connecting theories are described in [BAARDA, 1975, 1978, 1979a, 1979b].

Concerning the computational part of the mentioned problems, the following may be remarked.

The modular computing system for the l.s.a. and statistical analysis of geodetic data SCAN-II is operational for several applications in one, two and three dimensional coordinate systems. A first publication on the basic ideas for this system was given in 1975, the detailed description of the systems and of the techniques and theory which are used is in preparation. As the system has full capabilities for the handling of correlated observations and for the application of sequential adjustment techniques, it is also suitable for the analysis of deformation problems.
The adjustment of the Unified European Levelling Network (U.E.L.N. 1973), to be carried in 1978 and 1979, is also to be completed with use of a subset of the SCAN-II system. The results of the internal adjustment of the West-European part of the network will be presented at the IAG General Assembly in Canberra.
Future developments of the software system are to be found in the introduction of more refined reordering procedures for the handling of sparse matrices, the design of networks in an interactive mode and the extension of the systems for more geodetic applications. The Computing Centre participated in the Readjustment of the European Triangulation Network (RETrig), for the solutions RETrig-I and RETrig-II (ED-77). In cooperation with the RETrig Computing Centre at Munich, a start has been made with the statistical analysis of the data and the intermediate results of the adjustments. This will be continued in future, as the strengthening of the European network by use of satellite-derived positional data is foreseen (RETrig-III).

4.2 Publications

BAARDA, W. (1975) — Difficulties in establishing a model for testing crustal movements. In: Progress in Geodynamics — North-Holland Publ. Comp., Amsterdam/New York

BAARDA, W. (1976a) — Report on activities in IAG Special Study Group 4.14. — Travaux de l'A.I.G., tome 25, Paris

BAARDA, W. (1976b) — Reliability and precision of networks - VII Int. Kurs für Ingenieursmessungen hoher Präzision, 29 Sept. — 8 Okt. '76. Beiträge, Band I, TH Darmstadt, Inst. für Geodäsie.

BAARDA, W. (1977) — Measures for the accuracy of geodetic networks — IAG Int. Symp. on Optimization of Design and Computation of Control Networks, Sopron, Hungary.

BAARDA, W. (1978) — Mathematical models — Lecture, 25th anniversary of the foundation of the OEEPE, Vienna, OEEPE publ. off. No 11.

BAARDA, W. (1979a) — A connection between geometric and gravimetric geodesy. A first sketch — Netherlands Geodetic Commission Publ. on Geodesy, New Series 6, No. 4, Delft

BAARDA, W. (1979b) — Mathematical geodesy in relation to the Netherlands Geodetic Commission. In: The Centenary of the Netherlands Geodetic Commission — Netherlands Geodetic Commission, Delft

KOK, J.J. (1975) — Geodesie en kleinste kwadraten: De wisselwerking van numerieke algorithmen en bepaalde modeltheorieën. Publication R94, Computing Centre, Geodetic Institute, Delft University of Technology — In Dutch.

KOK, J.J. (1977a) — The B-method of statistical testing applied to RETrig computations. Paper presented at the Symposium of the IAG Subcommission for RETrig. In: Report on the symposiums of the IAG subcommission European Triangulation, Brussels, 1977 — pp. 106-116

KOK, J.J. (1977b) — An algorithm for the reduction of sparse symmetric matrices. Paper presented at the Symposium on Optimation of Design and Computation of Control Networks, Sopron.

MIERLO, J. VAN (1975a) — Statistical analysis of geodetic networks designed for the detection of crustal movements. In: Progress in Geodynamics — North-Holland Publ. Comp., Amsterdam/New York

MIERLO, J. VAN (1975b) — Testing and adjusting 2- and 3-dimensional networks for detecting deformations — FIG-Symp. on Deformation Measurements, Krakow.

MIERLO, J. VAN (1977a) — Systematic investigations on the stability of control points — XV FIG Congress of Surveyors, Stockholm, Paper 606.2

MIERLO, J. VAN (1977b) — Statistical analysis of geodetic measurements for the investigation of crustal movements — Int. Symp. on Recent Crustal Movements, Stanford University, Palo Alto, California. Tectonophysics, 52, pp. 457-467

MIERLO J. VAN (1978) — A testing procedure for analysing geodetic deformation measurements — 2nd Int. Symp. on Deformation Measurements by Geodetic Methods, Bonn

MIERLO, J. VAN (1978-1979) — Internal reports on S-transformations and generalized inverse matrices and on deformation measurements. Computing Centre of the Delft Geodetic Institute, Delft University of Technology — In Dutch

STRANG VAN HEES (1977) — Orientation of the ellipsoid in geodetic networks. Delft Progress Report No. 33, pp. 35-38

5 PHYSICAL INTERPRETATION

5.1 Recent Movements of the Earth's Crust

5.1.1 *Measurements*

At the request of the subcommission Crustal Movements of the Netherlands Geodetic Commission the precise levellings across a number of faults between Hilvarenbeek and Horst were repeated in 1975 (several measurements since 1926) and across the saltdomes near Schoonlo in 1978 (first measurement 1967), and Winschoten in 1978 (first measurement 1967).

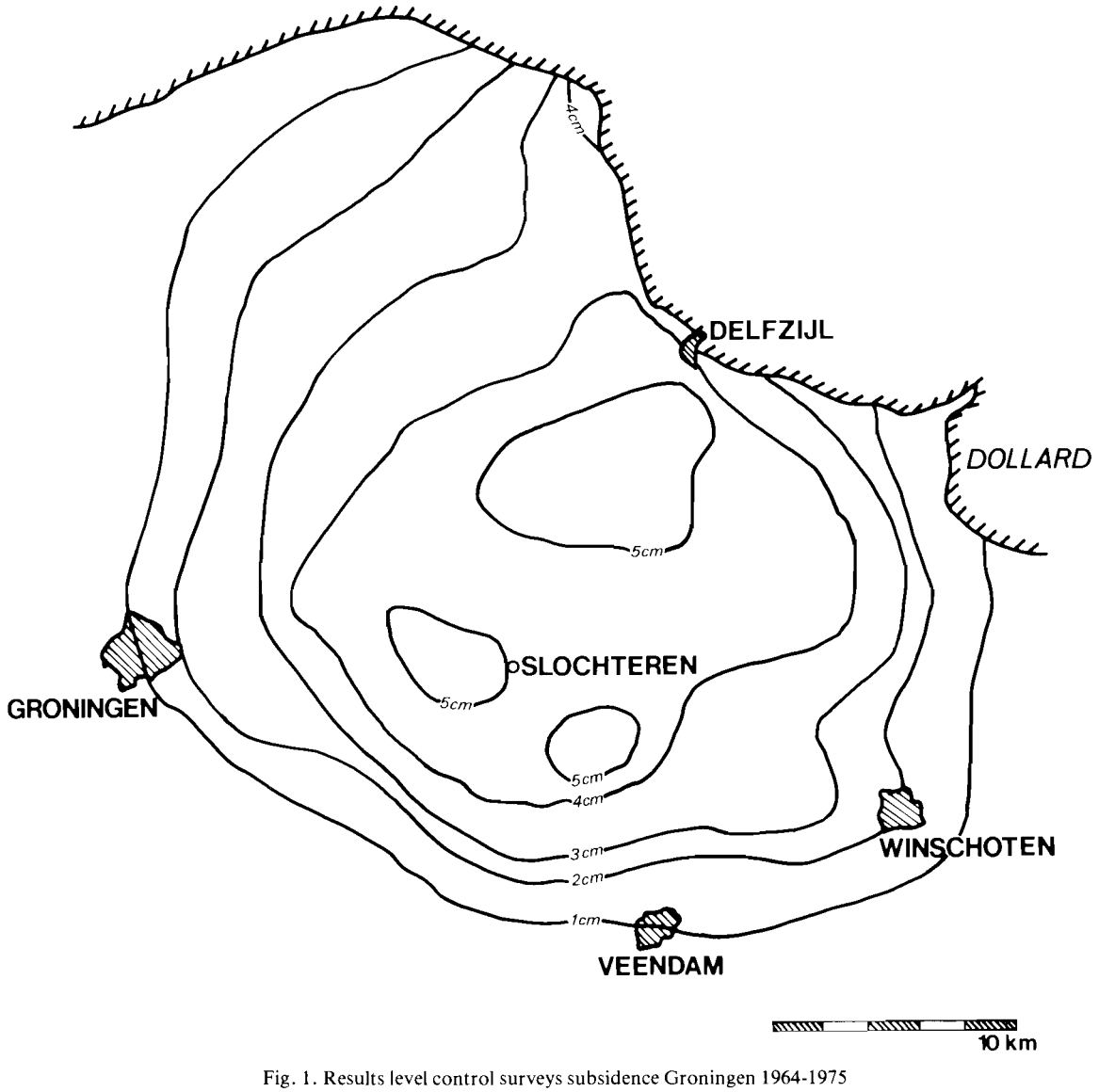

Fig. 1. Results level control surveys subsidence Groningen 1964-1975

5.1.2 *Levellings in mining areas*

The fourth levelling across the gasfield Groningen was carried out in 1975 (previous levellings in 1964/1965, 1968/1969 and 1972). The network consisted of 1502 km of levelling, 88 circuits, 188 nodal points and 279 sections. The standard deviation of this levelling was 1.1 mm/km. Since the beginning of the gas production in 1965, a surface subsidence of 2.5 cm was found in the centre of the field, see Fig. 1.
In 1978 a fifth levelling was carried out. The network consisted of 1471 km of levelling, 92 circuits, 205 nodal points and 292 sections. The computation of this levelling net is not completed yet.

5.2 *Publications*

DE JONGE, P.H. — Waterpassingen over het Groninger gasveld in 1975. Geodesia, 1977, No. 2, pp. 43-52 — In Dutch.