Complementary Gravity Observations in the Faroe Islands

By Svend Saxov[1])

Abstract

During the North Atlantic Seismic Project in 1972 possibilities occurred to establish some 130 complementary gravimeter stations in Vágar, Streymoy and Suðuroy.

Because problems arose in connection with the stability of the temperature of the Worden Master Gravimeter employed, a special investigation with regard to cooling and heating of the gravity meter was undertaken.

The Bouguer anomalies including topographic corrections are depicted at the maps and the isogal picture is discussed. It is concluded that the Faroe Islands are considered as one unit gravimetrically.

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In the summer of 1972 the Laboratory of Geophysics at Aarhus University participated in the North Atlantic Seismic Project (NASP), which was headed by Professor, Dr. M. H. P. Bott at Durham University, Great Britain.

During the NASP campaign opportunities occurred to carry out complementary geophysical investigations, e. g. K. Overgaard Hansen & V. Halskov Søndergaard (1973) made a systematic study of the magnetic susceptibility of the basaltic rocks. Furthermore, a series of detailed gravimetric observations

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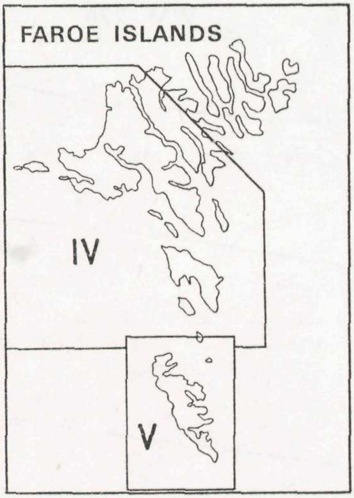


Fig 1. *Key map.*

was executed. Like the most recent gravity measurements (Saxov 1971) the observations were carried out along the old cairn footpaths (tracks) because the geodetic levelling lines follow the old cairn footpaths, the levelling being effected during 1895—1899 (Nørlund 1944). In recent years a net of roads has been constructed in the Faroe Islands, and as a consequence of this road building, the old cairn footpaths are not in regular use, and the cairns become dilapidated. That made the location of the cairns troublesome and retarded the actual gravimetric surveying. In Fig. 1 the areas of observations are indicated.

Worden Master gravimeter No. 779 was employed during the gravimetric survey. In Fig. 2 is given the drift curve at station Tórshavn 6, which was also used as base station during the 1970 survey (Saxov 1971). The drift curves for 1970 and 1972 are almost identical giving a small negative drift rate for the first two days, and an almost linear drift rate of the order of 0.01 mGal per hour for the remaining period. The drift curve for the time July 4th to 8th, and July 21st to 23rd is

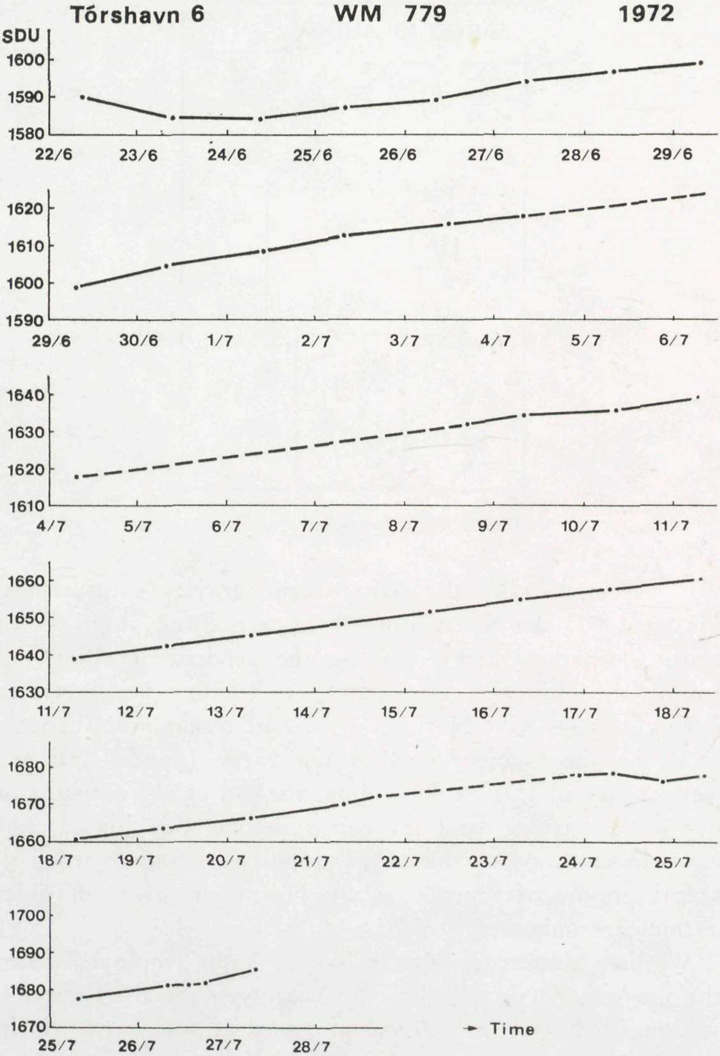
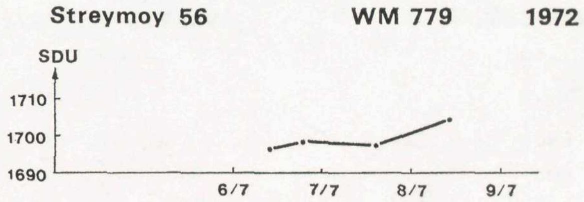


Fig. 2. *Drift curve for Worden Master gravimeter No. 779 at station Tórshavn 6; the mean value is 0.27 mGal/day.*



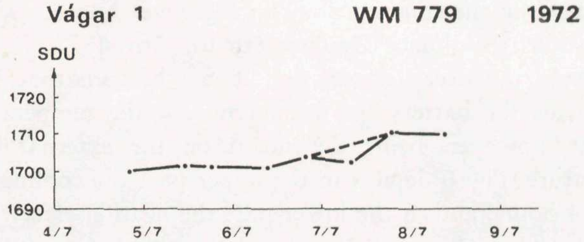


Fig. 3. *Drift curve for Worden Master gravimeter No. 779 at station Streymoy 56 and Vágar 1.*

given by a dashed line, because the gravimeter was then used either in Vágar, Streymoy or Suðuroy.

It has been mentioned that certain problems in locating the cairns gave rise to a slow speed, and with observers being untrained in walking in the Faroeish terrain the measurements proceeded at a slow pace which means long hours. Unluckily, the batteries for the gravimeter turned out to be worn-out, and during the long days' work the temperature dropped to lower values than prescribed, resulting in lower meter readings. That is demonstrated in Figs. 3 and 4 giving the drift curves for Vágar 1 and Streymoy 56, and Suðuroy 1, respectively.

Since no systematic investigation regarding cooling and heating of the Worden gravimeter with respect to time and value had been carried out, a series of observations was accomplished from July 29th to August 6th, 1972. The meter

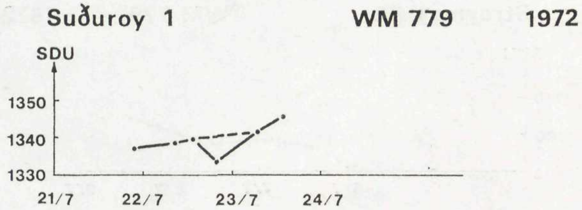


Fig. 4. *Drift curve for Worden Master gravimeter No. 779 at station Suðuroy 1.*

was placed on the concrete floor in a garage. Another series of observations took place October 8th to 10th, 1972. In Fig. 5 is depicted the decay curve, and it can be seen that 5 to 6 hours after the battery has been removed the temperature is constant, however, being dependent on the external (room) temperature. Fig. 6 depicts in the upper part the cooling effect during 4 hours, and in the lower part the heating effect, which is 4 times faster.

In order to obtain an idea of the drift curve in periods where the battery has been fixed and removed, the drift curves for the time July 29th to August 6th and for October 4th to 11th are shown in Fig. 7, in the upper part and the lower part, respectively. It can be concluded that the overall drift is independent of interruptions in the current supply. It is also clearly demonstrated that it takes between 1 and 2 days before the drift is normal when the meter has been without power supply for several days. Furthermore, the average value at decreasing temperature is a decrease of 0.3 SDU per °F.

The results obtained with regard to the drop in temperature have been utilized (Figs. 3 and 4), the largest correction being 0.45 mGal.

Some 130 new gravimetric stations were measured; 26 in Vágar, 63 in Streymoy, and 41 in Suðuroy. The gravimetric observations have been reduced in the usual manner. The geographical coordinates have been computed from the topographic maps on the scale of 1:20.000. The elevations of the

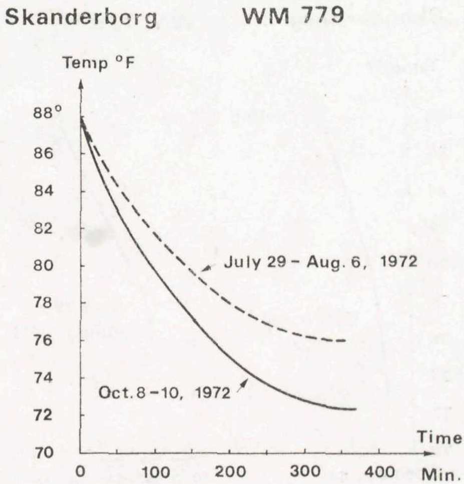


Fig. 5. *Decay curve (cooling) for Worden Master gravimeter No. 779.*

stations are given in metres. A density value of 2.67 g/cm^3 has been employed. Theoretical gravity has been taken from the tables published by Andersen (1956). That means that the International Formula of 1930 has been preferred (Lambert & Darling, 1931) due to the comparison with the previous gravity value (Saxov 1969 and 1971), even if a new International Formula of 1967 (IAG 1971) has been accepted. Likewise, it has been preferred to continue to apply Tórshavn 1 = 982.10833 Gal based on the Danish Reference Station Buddinge = 981.55800 Gal as the Faroeish reference station (Saxov & Spellauge 1967; Saxov 1969) even if newer values have been defined (Morelli et al. 1971; Morelli 1976).

Terrain corrections are computed according to Hammer (1939) and Bible (1962). In the rather time-consuming computation of the terrain corrections topographic maps on the scale of 1:20.000 and 1:00.000, besides sea charts of the Faroeish Sea have been used. The computations have been carried out for the zones A to M.

In the following table we have given the number of the

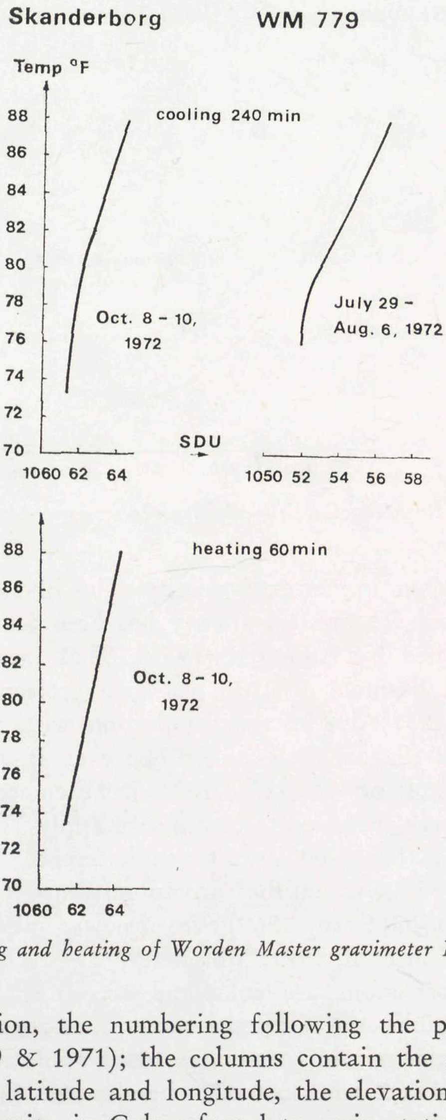


Fig. 6. *Cooling and heating of Worden Master gravimeter No. 779.*

gravity station, the numbering following the previous lists (Saxov 1969 & 1971); the columns contain the geographical coordinates' latitude and longitude, the elevations in metres, measured gravity in Gals referred to main station Tórshavn No. 1, Free Air anomaly, ordinary Bouguer anomaly, and Bouguer anomaly including topographic correction, the anomalies being expressed in mGals.

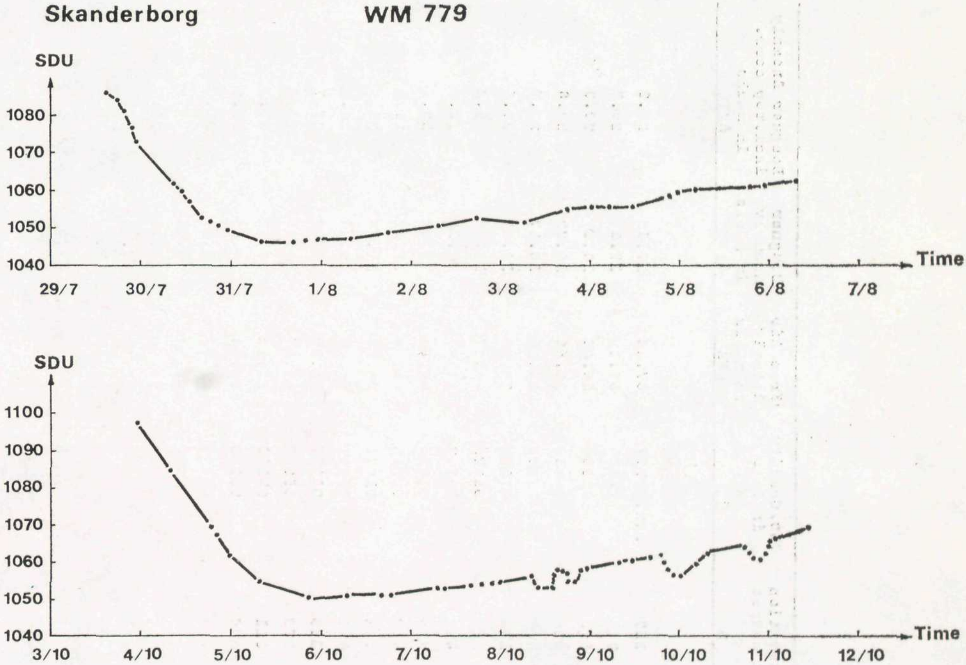


Fig. 7. *Drift curve for Worden Master gravimeter No. 779 at station Skanderborg during connection and disconnection of the battery.*

Station No.	Longitude W. of Grw. λ	Latitude ϕ	Elevation in metres H	Obs. Gravity in Gals $\ddot{g}$	Free Air Anomaly in mGals ΔgFA	Bouguer Anomaly in mGals ΔgBC	Bouguer Anomaly incl. top corr. in mGals ΔgTC
Streymoy							
116	07°09'19".6	62°10'30".3	357	982.03777	57.48	17.53	20.9
117	07°09'28.2	62 10 56.2	356	03864	57.50	17.67	20.7
118	07 09 25.7	62 11 18.9	352	03890	56.06	16.67	20.3
119	07 08 52.8	62 11 47.2	328	04436	53.52	16.82	20.8
120	07 07 39.7	62 12 18.5	424	02598	64.12	16.67	20.9
121	07 06 33.3	62 12 29.6	183	07295	36.48	16.01	20.5
122	07 10 43.3	62 15 13.6	270	05629	43.27	13.06	19.8
124	07 10 31.1	62 15 36.3	427	02702	61.97	14.20	19.9
125	07 10 31.3	62 15 52.5	466	01856	65.23	13.08	19.1
126	07 10 28.7	62 16 02.9	460	02216	63.24	15.28	21.4
127	07 10 33.0	62 16 20.1	521	01071	73.78	15.48	21.9
128	07 09 55.8	62 16 40.3	440	02801	65.66	16.42	22.4
129	07 09 18.5	62 16 54.0	329	05077	53.89	17.07	23.7
130	07 07 41.2	62 10 19.5	270	05349	46.57	16.36	20.3
131	07 06 37.7	62 10 34.5	311	04569	51.11	16.31	20.3
132	07 05 46.2	62 10 39.8	395	03209	63.33	19.13	20.8
133	07 04 38.3	62 10 37.4	394	03165	62.63	18.54	21.0
134	07 03 49.9	62 10 38.8	408	02890	64.17	18.51	22.4
135	07 03 29.3	62 10 57.0	381	03333	59.90	17.26	21.7
136	07 03 05.8	62 10 54.4	341	04185	56.12	17.96	22.0
137	07 02 21.5	62 11 02.3	170	07550	36.84	17.82	22.2
138	07 03 24.5	62 09 37.3	352	03866	57.93	18.52	21.2

139	07°03'36"8	62°09'13"9	354	982.03754	57.90	18.29	21.3
140	07 03 32.4	62 08 46.7	371	03517	61.35	19.84	21.6
141	07 04 30.5	62 08 53.7	266	05491	48.54	18.77	21.5
142	07 03 55.8	62 08 38.2	410	02650	64.90	19.02	21.7
143	07 03 43.2	62 08 23.4	365	03546	60.27	19.43	22.0
144	07 02 58.9	62 08 09.2	424	02263	65.95	18.50	22.2
145	07 02 31.1	62 07 54.0	312	04609	55.16	20.25	22.4
146	07 03 44.4	62 08 00.3	335	04163	57.66	20.17	22.5
147	07 03 59.5	62 07 45.4	283	05131	51.60	19.94	23.0
148	07 04 04.9	62 07 29.2	140	07873	35.23	19.57	23.0
149	06 56 37.7	62 08 55.1	130	08206	33.70	19.15	23.3
150	06 57 10.9	62 08 54.4	220	06346	42.88	18.26	22.4
151	06 57 42.7	62 08 51.8	208	06522	40.99	17.71	22.8
152	06 58 26.8	62 08 40.7	436	01921	65.57	16.78	21.9
153	06 59 05.6	62 08 45.8	646	981.96625	77.32	5.03	21.7
154	06 59 26.2	62 08 19.9	416	982.02440	65.03	18.38	22.6
155	06 59 50.9	62 08 05.9	339	03949	56.65	18.71	23.5
156	06 49 36.8	62 03 50.0	165	07574	44.52	26.06	28.8
157	06 49 58.9	62 03 59.1	181	07224	45.77	25.51	27.8
158	06 50 22.3	62 04 15.0	224	06371	50.18	25.11	27.3
159	06 50 43.0	62 04 31.9	309	04756	59.91	25.33	27.9
160	06 50 59.6	62 04 51.9	375	03456	66.86	24.89	28.3
161	06 51 16.2	62 05 10.7	454	01726	73.54	22.74	28.6
162	06 51 43.8	62 05 31.4	519	00317	79.08	21.11	27.5
163	06 52 05.9	62 05 39.9	552	981.99353	79.45	17.68	27.6
164	06 53 23.2	62 05 37.2	385	982.02759	62.03	19.05	26.9

165	06°46'48"9	61°57'33"2	265	982.05123	58.72	29.07	32.6
166	06 47 19.1	61 57 53.3	301	04372	61.90	28.22	32.1
167	06 46 54.4	61 58 13.3	266	05290	59.86	30.09	32.2
168	06 46 28.3	61 58 39.3	245	05752	57.46	30.04	32.0
169	06 46 42.0	61 58 59.3	273	05184	60.00	29.45	32.1
170	06 46 24.1	61 59 08.4	193	06835	51.63	30.03	32.0
171	06 46 25.5	61 59 22.0	177	07199	50.05	30.25	32.1
172	06 51 35.2	62 02 34.3	365	03273	64.81	23.97	28.6
173	06 50 52.5	62 02 30.3	257	05725	56.08	27.32	29.9
174	06 50 22.2	62 02 16.1	227	06332	53.18	27.78	29.4
175	06 49 29.8	62 02 04.4	343	03875	64.66	26.28	29.3
176	06 48 44.4	62 02 27.7	280	05115	57.13	25.80	29.4
177	06 47 52.0	62 02 33.6	179	07330	47.99	27.96	29.8
178	06 47 31.4	62 02 17.4	182	07325	49.21	28.84	30.1
179	06 47 13.5	62 02 04.4	149	08001	46.05	29.38	30.5
Suðuroy							
39	06 57 59.1	61 37 47.1	220	02591	44.35	19.73	25.6
40	06 57 59.2	61 38 00.7	120	04933	36.62	23.16	27.3
41	06 57 29.3	61 38 05.3	96	05512	34.61	24.16	26.6
42	06 57 08.8	61 37 53.6	65	06113	31.60	24.53	27.1
43	06 57 04.7	61 37 42.6	90	05468	33.09	23.02	26.7
44	06 57 00.6	61 37 28.4	234	02483	47.98	21.80	26.9
45	06 56 51.0	61 37 13.5	367	981.99725	61.76	20.69	27.4
45a	06 56 48.3	61 37 12.2	366	99731	61.54	20.58	27.3
46	06 56 25.1	61 37 09.6	373	99515	61.59	19.85	27.3

47	06°56'38".7	61°37'01".8	331	982.00568	59.33	22.29	26.7
48	06 56 31.8	61 36 46.3	265	01954	53.15	23.50	26.7
49	06 56 26.3	61 36 32.0	214	02934	47.51	23.56	26.6
50	06 56 24.9	61 36 17.8	86	05308	32.04	22.42	25.4
51	06 50 38.0	61 34 06.1	151	03729	39.09	22.19	25.7
52	06 51 09.2	61 34 09.9	200	02713	43.96	21.58	25.9
53	06 51 14.7	61 34 10.6	208	02622	45.51	22.23	26.2
54	06 52 00.8	61 34 22.9	348	981.99940	61.63	22.69	26.5
55	06 51 28.3	61 34 37.8	382	99205	64.47	21.72	27.2
56	06 51 10.7	61 34 55.3	337	982.00202	60.18	22.47	26.4
57	06 52 29.3	61 34 23.5	397	981.98958	66.92	22.50	26.7
58	06 52 56.5	61 34 31.9	365	99553	62.82	21.98	26.7
59	06 53 26.3	61 34 40.3	356	99801	63.34	22.51	26.6
60	06 53 57.6	61 34 53.3	348	99909	60.68	21.74	26.2
61	06 53 27.8	61 35 16.6	322	982.00485	57.93	21.90	26.7
62	06 54 35.6	61 35 05.5	256	01728	50.22	21.58	26.9
63	06 55 16.4	61 35 21.1	51	06025	29.61	23.90	26.2
64	06 49 38.2	61 31 28.2	276	982.00979	53.48	22.60	26.8
65	06 49 38.2	61 31 08.8	200	02415	44.80	22.42	25.5
67	06 48 53.5	61 30 46.1	410	97796	63.90	18.02	26.9
68	06 48 52.2	61 30 37.7	294	982.00480	55.12	22.22	26.0
69	06 49 04.3	61 30 24.1	247	01500	51.09	23.45	25.7
70	06 48 49.4	61 30 07.9	228	01860	49.17	23.66	25.5
71	06 48 41.3	61 29 48.4	259	01228	52.83	23.85	26.0
72	06 47 37.7	61 29 56.9	220	02096	49.30	24.68	26.3
73	06 47 28.2	61 30 07.9	181	02890	44.97	24.71	26.6
74	06 47 06.6	61 29 57.5	185	02810	45.62	24.92	26.6

75	06°46'42".2	61°29'47".8	209	982.02358	48.72	25.33	27.1
76	06 46 20.6	61 29 38.1	211	02325	49.20	25.59	27.3
77	06 45 41.3	61 29 25.1	215	02224	49.71	25.65	27.5
78	06 45 06.2	61 29 17.9	189	02597	45.57	24.42	26.4
79	06 44 46.8	61 29 14.0	172	02978	44.21	24.96	27.1
80	06 46 51.6	61 30 36.4	158	03242	40.79	23.11	26.3
Vágar							
40	07 17 31.2	62 04 39.0	94	08664	32.48	21.97	24.6
41	07 16 51.2	62 05.11.7	190	07001	44.80	23.54	24.6
42	07 16 30.9	62 05 35.7	154	07705	40.23	23.00	24.2
43	07 16 20.2	62 05 57.8	130	08088	36.20	21.65	24.2
44	07 16 19.1	62 06 18.6	132	07974	35.25	20.47	23.5
45	07 15 28.6	62 06 51.8	209	06503	43.61	20.22	22.8
46	07 14 58.9	62 07 43.7	417	02367	65.36	18.69	22.2
46a	07 15 00.4	62 07 46.3	420	02290	65.54	18.46	22.1
47	07 15 03.5	62 08 10.6	355	03530	57.29	17.57	21.7
48	07 14 21.2	62 08 52.2	163	07282	34.70	16.46	21.8
49	07 14 21.3	62 07 20.5	395	02847	63.85	19.65	22.6
50	07 13 42.4	62 07 02.5	438	01936	68.39	19.37	23.0
51	07 13 21.4	62 06 45.0	508	00406	75.05	18.20	22.8
52	07 12 49.4	62 06 27.6	473	01181	72.36	19.43	23.6
53	07 11 55.3	62 06 09.0	436	02036	69.88	21.09	24.2
54	07 10 40.6	62 05 55.6	490	00767	74.13	19.30	24.4
55	07 10 01.8	62 05 40.8	445	01620	69.08	19.28	24.5
56	07 09 50.6	62 05 28.5	391	02854	65.01	21.26	24.8
57	07 09 46.4	62 05 24.6	335	03940	58.67	21.18	24.2

58	07°09'18".6	62°05'05".9	283	982.05004	53.65	21.99	25.3
59	07 15 05.3	62 05 31.5	146	07573	36.54	20.20	23.2
60	07 14 29.6	62 05 42.6	161	07419	39.39	21.38	24.3
61	07 14 15.7	62 05 40.1	191	06925	43.76	22.39	24.5
62	07 12 32.5	62 05 57.2	360	03522	61.53	21.24	24.1
63	07 12 18.7	62 05 59.9	391	02879	64.61	20.86	23.6
64	07 11 37.6	62 06 24.0	392	02764	63.27	19.41	23.3
65	07 10 59.2	62 06 42.2	228	06094	45.58	20.07	23.7

In Fig. 8 we present for area IV the Bouguer anomalies including the topographic correction according to the figures given in the last column in the table. Isogals are drawn with an equidistance of 1 mGal. It has been preferred to give the anomalies with one tenth of a milligal. That does not mean that the anomaly values are correct to this unit due to the topographic correction. Repeated calculations of this correction for a number of stations have given divergences up to 0.3 mGals. It has to be pointed out that in area IV are included areas I, II and III presented previously (Saxov 1971). An inspection of the anomaly picture in Fig. 8 gives occasion for the following remarks. Firstly, the anomaly curves from + 31 mGals to +22 mGals at the southern part of Mykines, Vágar, Koltur and Hestur must run along the western edge of Sandoy in order to fit into the anomaly picture of Suðuroy. Secondly, the minimum in the northern part of Streymoy which was suggested at the former gravity map (Saxov 1969) appears now more clearly, and there is reason to believe that the +21 mGal curve closes in the water westwards. Thirdly, a comment concerning the changing features of Streymoy. It was remarked (Saxov 1971) that it was a surprise to locate a gravity minimum northwest of Kirkjubøur. The new measurements have only emphasized this minimum, and they have also given rise to several local features, e. g. the minimum north of Kaldbak. Finally, it may be remarked that the gravity picture seems to indicate that the geology of Streymoy may not be so simple as previously believed. In this connection it can be mentioned that there are inconsistencies in the seismic records in the Tórshavn region (Casten 1974; Bott et al. 1976). Also in the investigation by Pálmason (1965) an unsolved problem remained at Kollafjørður along the profile Tórshavn—Hvalvík. This problem could equally well be due to inconsistencies in the Tórshavn region.

Anyway, the seismic surveys in 1969, 1972, and 1975 have all given reliable records from the northern part of Streymoy as well as from Vágar and the northern part of Eysturoy

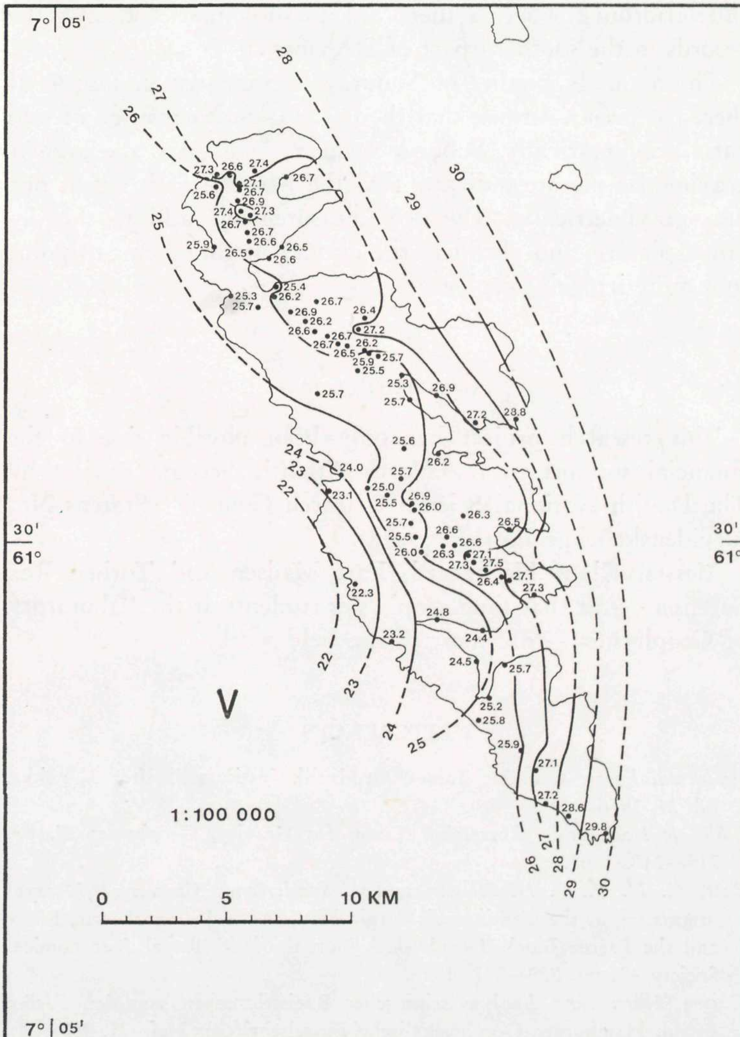


Fig. 9. *Bouguer anomalies including topographic correction in Suðuroy (area V).*

(Fuglafjørður), whereas there are question marks against the records in the southern part of Streymoy.

The anomaly picture of Suðuroy is presented in Fig. 9. If there has been a surmise that the Faroe Islands consisted of two parts gravimetrically, Suðuroy being the one part, the present gravimetric picture indicates that the Faroe Islands act as one unit gravimetrically. The new measurements add to the detailed picture, and also here the gravity picture seems to point to a more irregular geology.

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ÚRTAK

Tá North Atlantic Seismic Project varð framt á sumri 1972 bar í hesum tíðarskeiði til at gera nakrar tyngdarmátingar til ískoytis, og vórðu so statt um 130 nýggjar støðir valdar í Vágum, Streymoy og Suðuroy. Trupulleikar vóru við tólunum, so at hin ásetti hitastillarahitin kundi ikki verða hildin. Tí varð eftir at mátingarnar vóru av, gjørd serlig kanning viðvíkjandi køling og hiting av tyngdarmátinum. Bouguer frávikini saman við staðfrøðiligari beining eru sett á kort, og myndin av frávikunum verður umrødd. Úrslitið er tað, at Føroyar tyngdarmáti viðvíkjandi eru at rokna sum ein eind.