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Gravity measurements in eclogite mapping, Naustdal, Sogn og Fjordane, 1999

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REPORT

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Gravity measurements in eclogite mapping, Naustdal , Sogn og Fjordane, 1999

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NGU/ Rio Tinto Iron & Titanium

County:
Sogn og Fjordane

Commune:
Naustdal

Map-sheet name (M=1:250.000)
Florø

Map-sheet no. and -name (M=1:50.000)
1218 III Naustdal, 1217 IV Bygstad

Deposit name and grid-reference:
Bygdahaugen 32V 3210 68250 (WGS84)

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Summary:

The gravity measurements in the region between Naustdal and Engebø have been supplemented with 6 profiles. The objective of the measurements was to confirm the anomalies and the size of the indicated bodies from the 1998 investigations.

Two profiles east of Naustdal eclogite deposit have shown that the deposit have a limited extension to the east.

In the area east of Bygdahaugen, four profiles have confirmed the anomalies from 1998, and have better mapped the extension of the eclogite bodies. All profiles in this area indicates eclogite bodies, and the result from the modelling support the conclusions from 1998. The size of the possible eclogite body seems to be in the order of 400 mill. tons.

Keywords: Geofysikk	Gravimetri	Eklogitt
Rutil	Modellforsøk	
		Fagrapport

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APPENDIX

MAPS

1. INTRODUCTION

Gravity measurements have been carried out in the mountainous area between Naustdal and Engebø in Sogn og Fjordane county, western Norway in 1998 (Elvebakk et al. 1999). The objective of the gravimetric survey was to detect new deposits of rutile-bearing eclogite like the known deposits in Naustdal and Engebø. The results showed that the gravity method is well suited for such investigations and the Naustdal deposit was clearly indicated by a strong anomaly. To the East of Bygdahaugen a new body with a possible density of 3400 kg/m^3 (eclogite) was indicated. To confirm the anomalies and size of the indicated deposits, more detailed investigations, both geophysical and geological, were recommended.

In 1999 the gravity measurements were extended with four profiles (11,12,13 and 14) at Bygdahaugen, and two profiles (15 and 16) near Naustdal. The overview map (map –01) shows the new profiles and the profiles from 1998. The main bedrock in the area is a granitic to granodioritic gneiss, in which the eclogite lenses occurs (Lutro and Ragnhildstveit 1996).

Data acquisition and leveling were performed from 31.08 to 05.09 1999 by Einar Dalsegg and Jomar Gellein. Data processing was done by Jomar Gellein. Bouguer and residual maps were made by Ola Kihle. Interpretation and modelling of gravity profile data were done by Einar Dalsegg.

2. THE GRAVITY METHOD AND DATA ACQUISITION

The gravity method is based on the attraction between all masses. In the gravity method the masses are a known mass inside the gravimeter and the underlying masses inside the Earth. Variations in the density of the bedrock varies the attraction forces between the masses which can be measured by the gravimeter. For this reason, measurements of the variation, with location, in the gravitational attraction forces can provide valuable information about subsurface geology. The gravity method is particularly useful in differentiating rock types which are not distinguishable by virtue of their magnetic or electric properties.

Several corrections have to be performed on the measured gravity data due to variations in latitude, elevation, time and terrain (surrounding masses). These corrections are very important. The terrain correction may give some uncertainty in the processed data in very rough terrain because of poor elevation data.

Data acquisition was carried out using a LaCoste & Romberg gravimeter (model G No. 569). Measurements were made along 6 profiles. Station interval was 100 m at the central part of the profiles and 200 m at the ends. The elevation (m.a.s.l.) in each point was calculated by

using a Sokkia (SET4B) electronic total station. Map –01 shows the investigated area with the profiles.

To correct for time variations in the gravity field and instrument drift, base station readings were made before and after measurements along profiles at a station located in Førde (UTM 32V 3316 68175 WGS84). This base station was tied to a gravity base station at Mo School of Agriculture in Førde (Statens kartverk, UTM 32W 3390 68147 WGS84) where the value of absolute gravity is known. Absolute gravity values could thus be obtained for all stations.

3. DATA PROCESSING

Bouguer anomaly values were calculated using software from the Norwegian Mapping Authority (Statens Kartverk, Mathisen 1976). Bouguer and terrain corrections were carried out using a standard density of 2670 kg/m^3. Terrain corrections were performed using 8 points with known elevation at four circles around each gravity station. Circle radii were 100, 200, 400 and 800 m. The elevations were extracted from the Norwegian Mapping Authority's database. A table of co-ordinates (geodetic datum ED50), absolute gravity, corrections and Bouguer anomalies is shown in appendix 1. Bouguer and residual anomaly maps were made using Oasis montaj system from Geosoft (Geosoft 1997). A third order polynomial surface was fitted to the Bouguer grid values and then subtracted to produce the residual gravity grid (Geosoft 1997).

Prior to modelling the data, a local gravity gradient was subtracted from the terrain corrected Bouguer anomaly. The gravity gradient was calculated from the trend in the Bouguer anomaly curves. All profiles show a linear trend in the Bouguer anomaly curve. The computed regional gradients may cause some inaccuracy in the size of the residual Bouguer anomalies. This is always a problem in gravity modelling. The modelled profiles are straight lines between two points close to each end of the measured profiles. Gravity stations along the profile are projected to this line, and this will also cause some inaccuracy in the modelling.

Modelling of the data was performed using the 2.5D GMM (Gravity and Magnetic Modelling) program from Swedish Geological Company (1991). The length of the modelled body is 1000 m, 500 m to each side of the profile. For presentation of the models and the model response curves, the Grapher program from Golden Software INC. was used.

4. INTERPRETATION – MODELLING

4.1 Bouguer anomaly map

Map –02 shows the Bouguer anomaly map including the measurements from 1998 (geodetic datum WGS 84). In addition to the stations measured in this project, several stations from NGUs database are implemented in the gridding of the Bouguer values. The map shows an increasing regional gradient from east to west.

The extension of the Naustdal eclogite deposit to the east are, after this years measuring, better mapped. There are no anomalies at profile 15 and this indicates that the Naustdal eclogite deposit do not continue so far to the east.

At Bygdahaugen, the map after this years measurements, are more detailed. The anomaly at profile 11 seems to be the eastern end of the eclogite in this area. From the modelling (see later) it is indicated eclogite bodies at every profile, and this represent a strike length of 3.5 km.

To enhance the local variations in the gravity field, it is necessary to make a residual map.

4.2 Residual map

Map –03 shows the residual gravity map of the investigated area (geodetic datum WGS 84). A third order polynomial surface was fitted to the Bouguer grid values and then subtracted to produce the residual gravity grid (Geosoft 1997). This map was produced to enhance the local gravity anomalies in the area. These residual values include some semi regional trends, and can not be used as a basis for the eclogite deposit modelling. The Naustdal deposit and the Bygdahaugen eclogite structure are after this years measuring better mapped. At Bygdahaugen, the map indicates two main bodies, one on both side of profile 13. The map also indicates possible eclogite bodies south of this two main bodies. At Naustdal the map indicates that the deposit have a limited extension to the east.

4.3 Densities and geological information

A geological map of the Førdefjord area, 1:50 000, (Lutro and Ragnhildstveit 1996) is used as a basis for the modelling. A part of the geological map covering the investigated area is shown in Map –04. The main rock type in the area is a granitic to granodioritic gneiss. Inside the gneiss unit there is a mixed unit of eclogite, amphibolite, metagabbro and grey gneiss.

Rock sampling has revealed average density values of 2700 kg/m^3 for the granitic gneiss, 2900 – 3000 kg/m^3 for the mixed unit and 3400 kg/m^3 for the eclogite (Korneliussen et al., 1996 & 1997). There are no drillholes in the investigated area to put constraints on the modelling of the rock unit towards depth.

In Naustdal, profile 16 crosses the outcrop of the known eclogite deposit, and profile 14 crosses the widest part of the outcropping eclogite at Bygdahaugen. This geological information is used in the modelling process.

4.4 Modelling

All the graphs in the appendix section are plotted from the South to the North seen from the East. There was no grid established in the area and the co-ordinates on the profiles do not correspond to each other. It will be possible to get satisfactory curve fitting with different models. The model presented are only one of them.

Profile 11

Profile 11 is located east of profile 5 (see Map –01). Appendix 2, page 1 shows Bouguer anomaly and terrain corrections. The calculated Bouguer anomaly and selected gradient are shown in appendix 3, page 1.

The residual Bouguer anomaly is about 1 mGal between co-ordinate 750 and 1100. Appendix 4, page 1 shows the model, response and observed data. The model shows a body with density 3400 kg/m^3 which is c. 100 m thick, 150 m deep and dipping c. 60^0 to the North. Close to the surface the model shows a smaller body with density 3200 kg/m^3. The main body could be the same body indicated on profile 5 (Elvebakk et al. 1999).

Profile 12

Profile 12 is located between profile 5 and profile 6 (see Map –01). Bouguer anomaly and terrain corrections are shown in appendix 2, page 2. Bouguer anomaly and an interpreted local gradient are shown in appendix 3, page 2.

The residual Bouguer anomaly shows a gravity anomaly between co-ordinate 800 and 1500 of 1 – 2 mGal. The main anomaly can be modelled with one or two eclogite bodies at the depth. Models, response and observed data are shown in appendix 4, page 2 and 3. The model with one body indicates the top of the body at 300 – 400 m. The depth extent is c. 400m and the body width is c. 300 m.

The model with two bodies at the depth indicates the top of the bodies at 250 – 300 m deep. Both bodies have a depth extent of 300 – 350 m. The bodies width are 150 and c. 200 m, and the dip is c. 60^0 . In both models three small bodies are indicated close to the surface.

The main bodies in the models could be the same body indicated on profile 5 an 6.

Profile 13

This profile is measured between profile 6 and 7 (see map –01). Terrain correction and Bouguer anomaly are shown in appendix 2, page 3. Bouguer anomaly and local gradient are shown in appendix 3, page 3.

The residual Bouguer anomaly shows a gravity anomaly at co-ordinate –1500 and one between co-ordinate –900 and –200. The size of the anomalies are c. 1.5 mGal. Models, response and observed data are shown in appendix 4, page 4. The anomaly at co-ordinate –1500 are modelled by one body, and the anomaly between co-ordinate –900 and –200 are modelled by three bodies. The body at co-ordinate –800 could be the same as the main body indicated on profile 7.

Profile 14

Profile 14 is located between profile 4 and 7 (see map –01). Terrain correction and Bouguer anomaly are shown in appendix 2, page 4. Bouguer anomaly and local gradient are shown in appendix 3, page 4.

A residual Bouguer anomaly of 1.5 - 2 mGal is indicated between co-ordinate –1000 and –350. Models, response and observed data are shown in appendix 4, page 5. The outcrop of an eclogite body has been mapped on this profile. This geological information has been put into the model. The upper part of the model body , density 3400 kg/m^3 , is c. 50 m thick and increasing to 250 m in the deeper part. This body is probably the same body as indicated on profile 4 and 7. Three bodies of a mixed unit of eclogite, amphibolite, metagabbro and gneiss (density 3000 kg/m^3) are put into the model in the southern part of the profile.

Profile 15

Profile 15 is located east of the Naustdal eclogite deposit (see Map –01). Terrain correction and Bouguer anomaly are shown in appendix 2, page 5. Bouguer anomaly and local gradient are shown in appendix 3, page 5.

The residual anomaly was so small that no modelling is done at this profile. This indicates that the Naustdal eclogite deposit does not continue so far to the east.

Profile 16

Profile 16 is located between profile 15 and 1b (see Map –01) and crosses the eastern end of the Naustdal eclogite deposit. Terrain correction and Bouguer anomaly are shown in appendix 2, page 6. Appendix 3, page 6 shows the Bouguer anomaly and the selected local gradient.

The largest residual Bouger anomaly is 1 mGal. Models, response and observed data are shown in appendix 4, page 6. The anomaly at co-ordinate 1300 (Naustdal eclogite deposit) is modelled with a 300 m deep and 100 m thick body. The dipping is c. 60^0 to the North. Three other bodies of eclogite are also put in the model in this profile to get satisfactorily curve fitting.

5. CONCLUSIONS

The gravity measurements in the region between Naustdal and Engebø have been supplemented with 6 profiles. The objective of the measurements was to confirm the anomalies and give a better estimate of the size of the indicated bodies (from the 1998 investigations).

Two profiles east of Naustdal eclogite deposit have shown that the deposit have a limited extension to the east.

In the area east of Bygdahaugen, four profiles have confirmed the anomalies from 1998, and have better mapped the extension of the ecogite bodies. All profiles in this area indicates eclogite bodies, and the result from the modelling support the conclusions from 1998 that the size of the eclogite body seems to be in the order of 400 mill. tons.

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TABLE OF CO-ORDINATES, ABSOLUTE GRAVITY, CORRECTIONS AND BOUGUER ANOMALIES

Location : Naustdal r=100,200,400,800m Project no: 284700 Fieldwork carried out in 1999 Processing performed in Nov 1999

Station Profile	Point	Lati-tude	Longi-tude	UTM-zone	UTM-East	UTM-north	Elevation (in m)	Absolute gravity	Bouguer corr.	Terrain corr.	Free air corr.	Bouguer-anomaly
11	0	61 31.27	5 39.50	32V	322280	6825568	375.00	981950.632	42.45	7.54	115.65	-4.10
11	100	61 31.21	5 39.50	32V	322268	6825445	367.62	981952.386	41.61	7.11	113.37	-4.16
11	200	61 31.15	5 39.49	32V	322255	6825336	391.83	981947.947	44.35	6.69	120.84	-4.22
11	300	61 31.09	5 39.49	32V	322255	6825225	431.41	981940.127	48.82	6.53	133.04	-4.41
11	400	61 31.01	5 39.48	32V	322235	6825084	512.45	981924.749	57.98	6.91	158.03	-3.45
11	500	61 30.95	5 39.53	32V	322275	6824960	548.26	981917.169	62.02	7.42	169.07	-3.45
11	600	61 30.89	5 39.51	32V	322250	6824855	587.57	981909.406	66.46	7.45	181.19	-3.45
11	700	61 30.84	5 39.50	32V	322235	6824757	605.56	981905.719	68.49	7.42	186.74	-3.58
11	800	61 30.76	5 39.50	32V	322225	6824614	648.69	981896.110	73.36	8.12	200.04	-3.94
11	900	61 30.70	5 39.48	32V	322210	6824497	637.38	981898.349	72.09	7.78	196.55	-4.18
11	1000	61 30.64	5 39.49	32V	322205	6824395	617.68	981902.377	69.86	7.20	190.48	-4.53
11	1100	61 30.56	5 39.49	32V	322205	6824248	578.49	981910.468	65.44	6.59	178.40	-4.58
11	1200	61 30.53	5 39.50	32V	322204	6824186	576.82	981910.479	65.25	6.72	177.88	-4.71
11	1300	61 30.47	5 39.49	32V	322194	6824085	536.07	981918.550	60.65	6.88	165.32	-4.37
12	0	61 30.37	5 38.62	32V	321410	6823930	720.00	981879.113	81.41	12.31	222.03	-2.30
12	100	61 30.44	5 38.62	32V	321415	6824054	697.22	981886.978	78.84	8.77	215.00	-2.56
12	200	61 30.49	5 38.66	32V	321457	6824150	695.57	981887.987	78.65	8.26	214.49	-2.44
12	300	61 30.55	5 38.68	32V	321485	6824267	687.61	981890.463	77.76	7.44	212.04	-2.40
12	400	61 30.60	5 38.69	32V	321500	6824345	685.52	981890.988	77.52	7.34	211.40	-2.46
12	500	61 30.65	5 38.72	32V	321525	6824453	707.27	981885.733	79.97	7.99	218.10	-2.87
12	600	61 30.70	5 38.72	32V	321536	6824542	721.49	981883.110	81.58	8.86	222.49	-1.90
12	700	61 30.75	5 38.74	32V	321558	6824625	726.51	981882.689	82.14	8.68	224.03	-1.58
12	800	61 30.81	5 38.76	32V	321582	6824744	721.71	981884.708	81.60	8.43	222.55	-0.82
12	900	61 30.83	5 38.62	32V	321460	6824782	718.40	981885.807	81.23	7.95	221.53	-0.85
12	1000	61 30.90	5 38.53	32V	321386	6824918	709.38	981887.974	80.21	7.69	218.75	-0.83
12	1100	61 30.94	5 38.49	32V	321352	6825000	697.17	981890.876	78.83	7.32	214.99	-0.74
12	1200	61 30.99	5 38.44	32V	321310	6825083	693.88	981892.103	78.46	7.08	213.97	-0.47
12	1300	61 31.03	5 38.36	32V	321246	6825170	692.00	981892.590	78.25	7.02	213.39	-0.47
12	1400	61 31.09	5 38.35	32V	321240	6825270	682.53	981895.038	77.18	6.60	210.47	-0.36
12	1500	61 31.14	5 38.39	32V	321280	6825370	665.71	981898.839	75.28	6.25	205.29	-0.25
12	1600	61 31.20	5 38.41	32V	321305	6825480	648.49	981902.548	73.34	5.71	199.98	-0.51
12	1700	61 31.25	5 38.45	32V	321344	6825565	634.26	981905.605	71.73	5.21	195.59	-0.80
12	1800	61 31.31	5 38.47	32V	321368	6825690	652.17	981901.966	73.76	5.35	201.11	-0.87
12	2000	61 31.42	5 38.53	32V	321430	6825877	674.87	981897.002	76.32	5.72	208.11	-1.14
12	2200	61 31.51	5 38.53	32V	321445	6826050	678.43	981896.981	76.72	5.60	209.21	-0.72
12	2400	61 31.61	5 38.62	32V	321530	6826234	681.92	981895.947	77.11	5.64	210.29	-1.16
12	2600	61 31.69	5 38.65	32V	321565	6826380	672.32	981898.161	76.03	5.51	207.33	-1.07
13	200	61 29.99	5 37.65	32V	320520	6823276	486.29	981930.098	55.02	4.83	149.97	-3.98
13	400	61 30.09	5 37.63	32V	320510	6823448	488.20	981930.075	55.24	4.54	150.55	-4.04
13	600	61 30.19	5 37.62	32V	320504	6823635	500.50	981928.338	56.63	4.39	154.35	-3.71

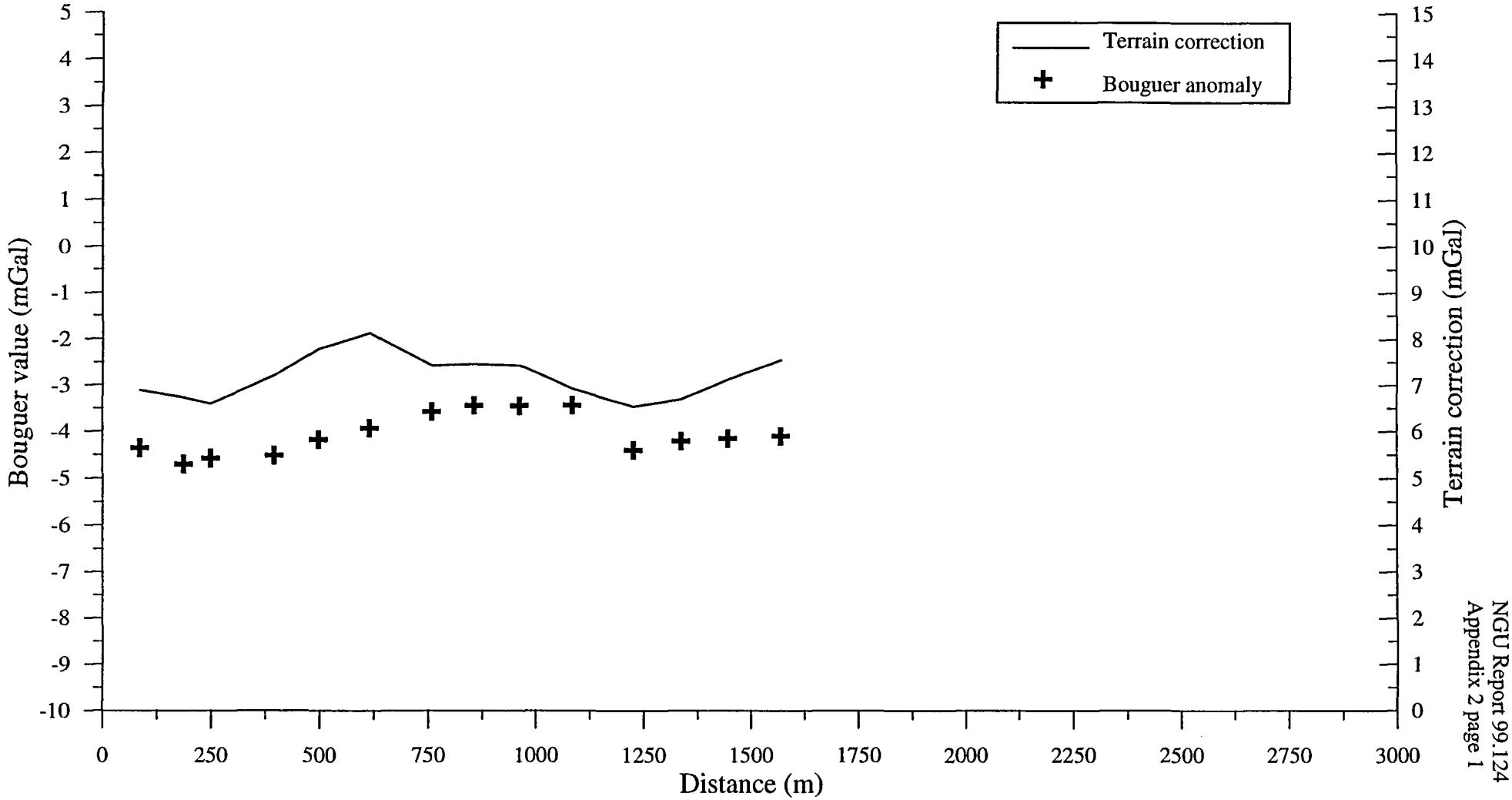
Location : Naustdal r=100,200,400,800m Project no: 284700 Fieldwork carried out in 1999 Processing performed in Nov 1999

Station Profile	Point	Latitude	Longitude	UTM-zone	UTM-East	UTM-north	Elevation (in m)	Absolute gravity	Bouguer corr.	Terrain corr.	Free air corr.	Bouguer-anomaly
13	800	61 30.28	5 37.66	32V	320550	6823808	534.66	981922.397	60.49	4.26	164.88	-3.17
13	1000	61 30.39	5 37.65	32V	320554	6824006	604.00	981907.662	68.32	5.97	186.26	-2.83
13	1100	61 30.45	5 37.68	32V	320584	6824115	572.62	981915.844	64.78	4.46	176.59	-2.35
13	1200	61 30.49	5 37.69	32V	320600	6824187	565.32	981917.499	63.95	4.47	174.33	-2.18
13	1300	61 30.54	5 37.70	32V	320615	6824280	546.13	981920.656	61.78	4.95	168.42	-2.35
13	1400	61 30.58	5 37.71	32V	320630	6824365	540.29	981922.061	61.12	5.68	166.62	-1.37
13	1500	61 30.63	5 37.73	32V	320648	6824447	544.23	981921.479	61.57	6.04	167.83	-0.87
13	1600	61 30.67	5 37.74	32V	320660	6824536	557.07	981919.267	63.02	6.17	171.79	-0.52
13	1700	61 30.73	5 37.73	32V	320655	6824636	578.01	981915.086	65.38	5.79	178.25	-1.04
13	1800	61 30.78	5 37.71	32V	320642	6824737	624.16	981905.429	70.59	5.70	192.48	-1.83
13	1900	61 30.83	5 37.65	32V	320600	6824830	651.63	981900.098	73.69	5.86	200.95	-1.70
13	2000	61 30.88	5 37.56	32V	320524	6824924	658.02	981900.135	74.42	5.54	202.92	-0.80
13	2200	61 30.97	5 37.45	32V	320430	6825090	660.27	981900.092	74.67	5.89	203.61	-0.17
13	2400	61 31.06	5 37.47	32V	320455	6825255	722.89	981887.504	81.74	6.43	222.92	-0.10
13	2600	61 31.15	5 37.43	32V	320430	6825436	727.17	981887.262	82.22	6.34	224.24	0.28
13	2800	61 31.24	5 37.35	32V	320368	6825595	714.72	981889.728	80.81	6.12	220.40	-0.04
13	3000	61 31.35	5 37.38	32V	320410	6825812	661.51	981901.506	74.81	4.97	203.99	0.06
13	3200	61 31.41	5 37.39	32V	320420	6825910	648.63	981903.866	73.36	4.59	200.02	-0.54
14	0	61 30.17	5 36.70	32V	319690	6823652	505.29	981928.233	57.17	4.54	155.82	-2.66
14	200	61 30.24	5 36.67	32V	319675	6823770	514.52	981926.922	58.21	4.87	158.67	-1.97
14	400	61 30.34	5 36.63	32V	319646	6823974	546.78	981921.748	61.86	4.55	168.62	-1.29
14	600	61 30.45	5 36.62	32V	319646	6824178	571.10	981917.827	64.60	4.32	176.12	-0.81
14	800	61 30.56	5 36.63	32V	319670	6824375	569.45	981918.664	64.42	4.27	175.61	-0.47
14	900	61 30.61	5 36.64	32V	319682	6824460	569.17	981918.741	64.39	4.74	175.52	-0.04
14	1000	61 30.63	5 36.64	32V	319680	6824505	566.47	981919.330	64.08	4.39	174.69	-0.33
14	1100	61 30.72	5 36.63	32V	319680	6824678	583.76	981915.163	66.03	5.76	180.02	0.12
14	1300	61 30.80	5 36.50	32V	319574	6824834	705.51	981889.720	79.77	7.01	217.56	-0.39
14	1400	61 30.84	5 36.46	32V	319544	6824908	709.31	981890.453	80.20	6.17	218.73	0.18
14	1500	61 30.89	5 36.44	32V	319534	6824995	708.76	981891.503	80.14	5.99	218.56	0.88
14	1600	61 30.94	5 36.42	32V	319516	6825086	708.20	981892.045	80.08	5.75	218.39	1.01
14	1700	61 30.99	5 36.39	32V	319495	6825178	709.35	981892.323	80.21	5.65	218.74	1.34
14	1800	61 31.04	5 36.36	32V	319475	6825280	709.95	981892.844	80.28	5.56	218.93	1.84
14	1900	61 31.09	5 36.31	32V	319432	6825365	712.43	981892.655	80.56	5.59	219.69	2.10
14	2000	61 31.13	5 36.27	32V	319407	6825447	707.75	981893.844	80.03	5.51	218.25	2.23
14	2200	61 31.22	5 36.21	32V	319355	6825620	704.11	981895.157	79.62	5.52	217.13	2.78
14	2400	61 31.32	5 36.15	32V	319314	6825804	706.03	981892.981	79.83	6.03	217.72	1.36
14	2600	61 31.42	5 36.14	32V	319314	6825995	686.63	981896.358	77.64	6.26	211.74	1.05
15	0	61 31.80	5 46.50	32V	328524	6826230	266.00	981969.250	30.12	4.44	82.04	-10.55
15	200	61 31.70	5 46.47	32V	328496	6826044	189.40	981985.113	21.45	3.80	58.41	-10.16
15	400	61 31.55	5 46.45	32V	328460	6825765	145.00	981993.755	16.42	3.38	44.72	-10.41
15	600	61 31.45	5 46.32	32V	328335	6825586	162.59	981990.468	18.42	3.21	50.14	-10.32
15	800	61 31.38	5 46.17	32V	328200	6825464	186.14	981986.419	21.08	2.75	57.41	-10.17
15	1000	61 31.27	5 46.13	32V	328154	6825265	197.30	981984.199	22.34	2,62	60.85	-10.15
15	1200	61 31.16	5 46.08	32V	328096	6825060	196.00	981984.264	22.20	2.65	60.45	-10.18
15	1400	61 31.06	5 46.07	32V	328080	6824870	195.90	981984.249	22.19	2.68	60.42	-10.06

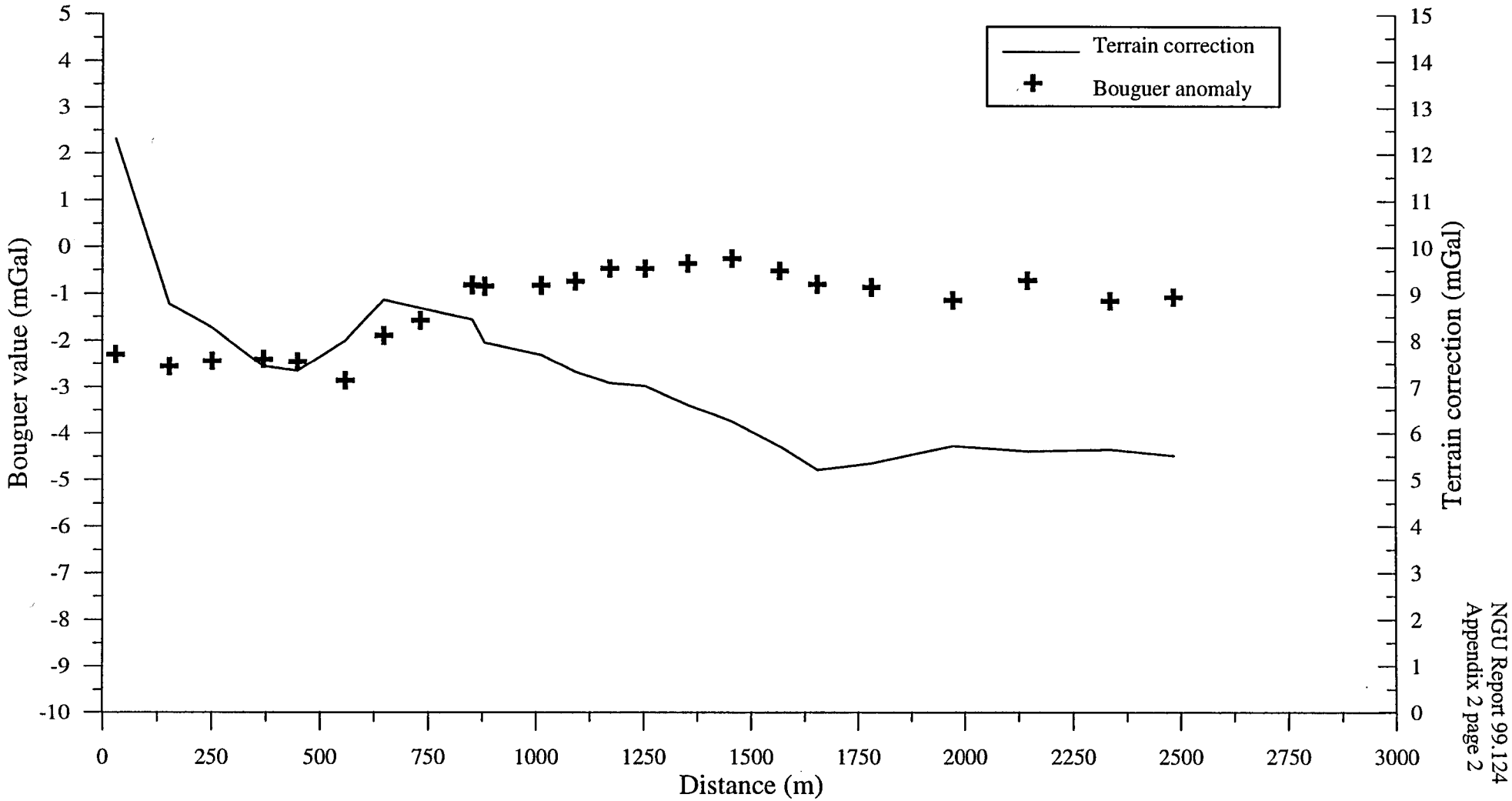
Location : Naustdal r=100,200,400,800m Project no: 284700 Fieldwork carried out in 1999 Processing performed in Nov 1999

Station Profile	Station Point	Latitude	Longitude	UTM-zone	UTM-East	UTM-north	Elevation (in m)	Absolute gravity	Bouguer corr.	Terrain corr.	Free air corr.	Bouguer-anomaly
15	1600	61 30.97	5 46.07	32V	328074	6824705	202.24	981982.458	22.90	2.62	62.37	-10.55
15	1800	61 30.84	5 46.06	32V	328052	6824460	239.51	981974.619	27.12	2.93	73.87	-10.68
15	2000	61 30.75	5 46.18	32V	328150	6824305	259.72	981970.336	29.41	2.93	80.10	-10.89
16	0	61 30.56	5 45.23	32V	327290	6823980	217.58	981979.072	24.64	2.89	67.10	-10.17
16	200	61 30.67	5 45.31	32V	327370	6824190	224.62	981978.497	25.44	2.63	69.27	-9.76
16	400	61 30.76	5 45.36	32V	327420	6824348	205.00	981982.545	23.22	2.39	63.22	-9.90
16	600	61 30.86	5 45.39	32V	327460	6824536	199.26	981983.776	22.57	2.49	61.45	-9.81
16	800	61 30.95	5 45.43	32V	327505	6824700	175.69	981988.647	19.90	2.63	54.18	-9.54
16	1000	61 31.04	5 45.57	32V	327636	6824855	164.94	981990.787	18.68	2.53	50.87	-9.72
16	1200	61 31.15	5 45.57	32V	327645	6825068	153.70	981993.439	17.41	2.87	47.40	-9.05
16	1400	61 31.23	5 45.59	32V	327670	6825210	161.81	981992.088	18.33	3.22	49.90	-8.59
16	1600	61 31.33	5 45.59	32V	327680	6825400	136.20	981996.370	15.43	3.63	42.01	-9.02
16	1800	61 31.43	5 45.64	32V	327730	6825580	108.85	982001.293	12.33	3.88	33.57	-9.31
16	2000	61 31.51	5 45.58	32V	327690	6825735	77.18	982007.842	8.74	4.18	23.80	-8.70
16	2200	61 31.64	5 45.73	32V	327835	6825974	93.85	982004.304	10.63	4.10	28.94	-9.26
16	2400	61 31.73	5 45.92	32V	328005	6826134	143.07	981995.348	16.21	3.43	44.12	-9.40
16	2600	61 31.83	5 45.97	32V	328060	6826318	155.22	981992.984	17.58	4.01	47.87	-8.94

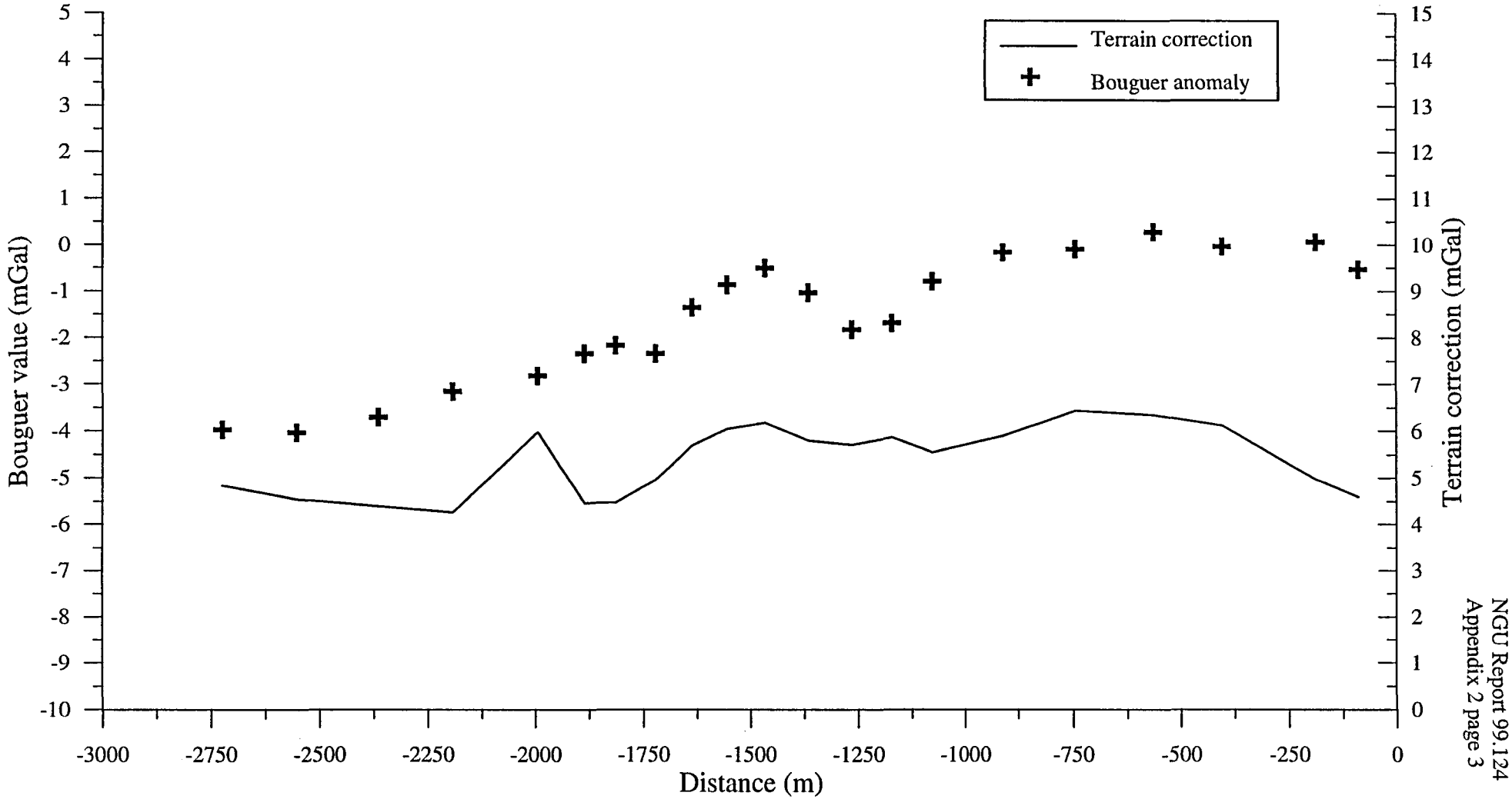
NAUSTDAL, gravity profile 11
Terrain correction and Bouguer anomaly values



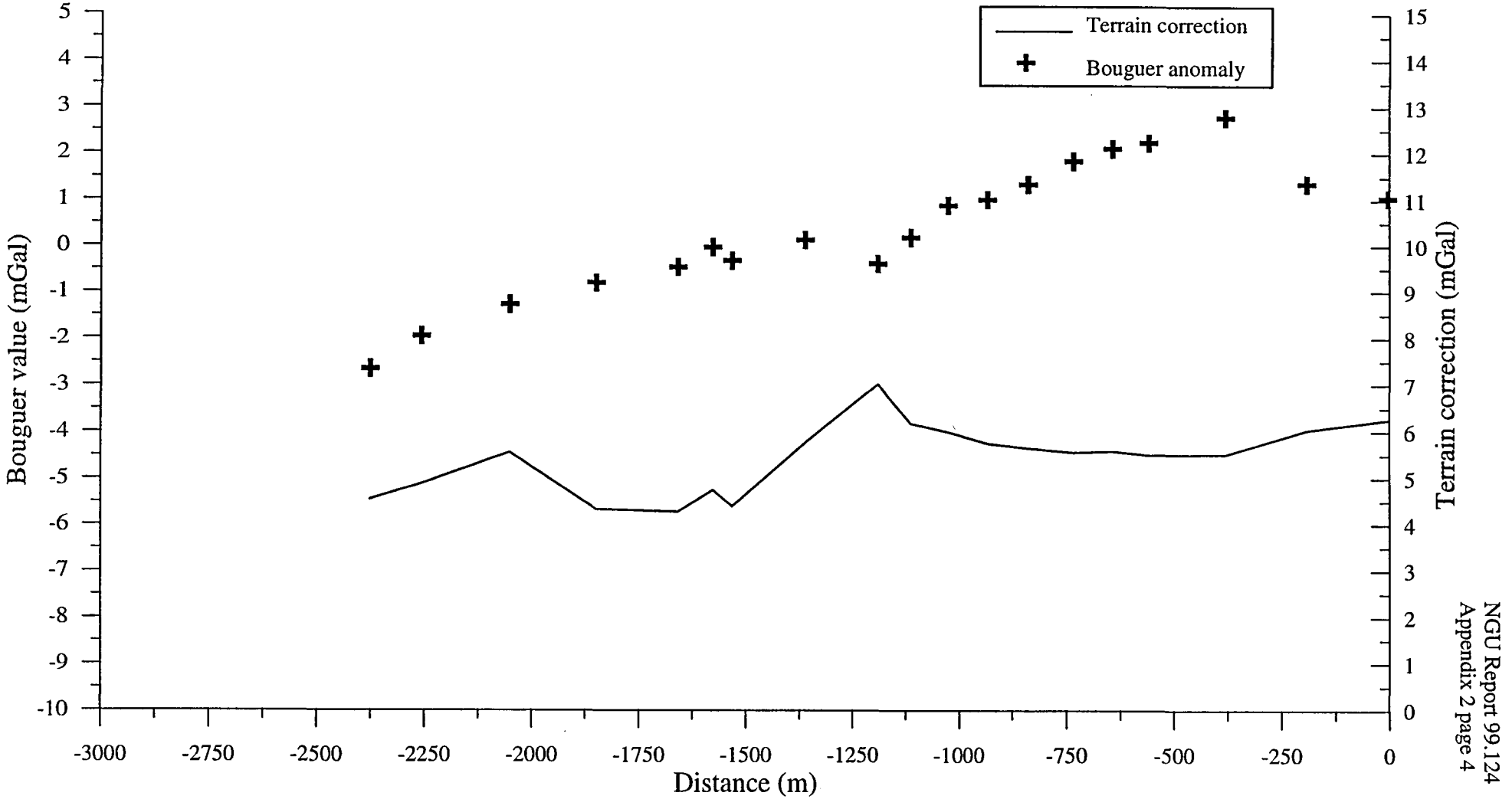
NAUSTDAL, gravity profile 12
Terrain correction and Bouguer anomaly values



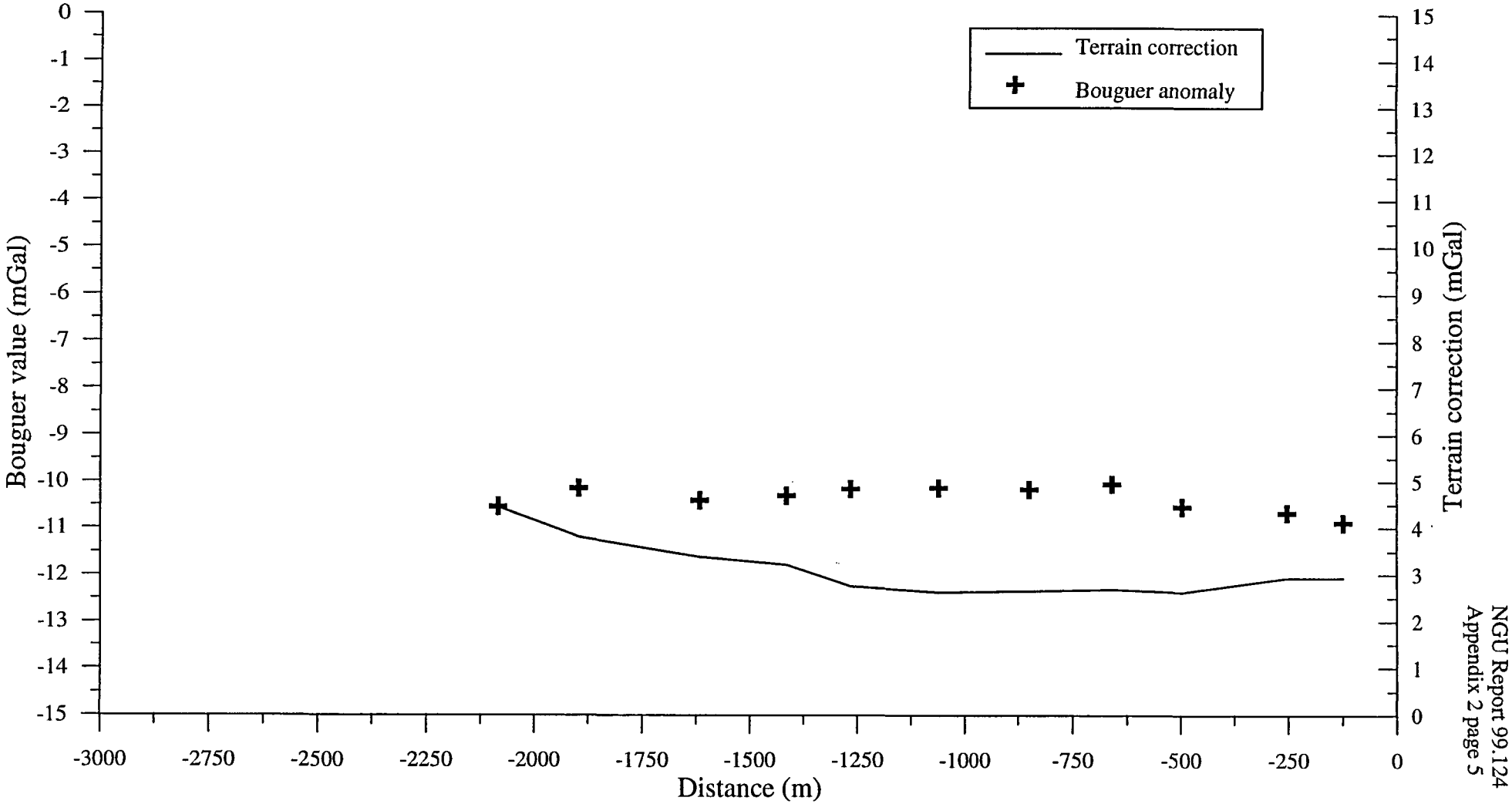
NAUSTDAL, gravity profile 13
Terrain correction and Bouguer anomaly values



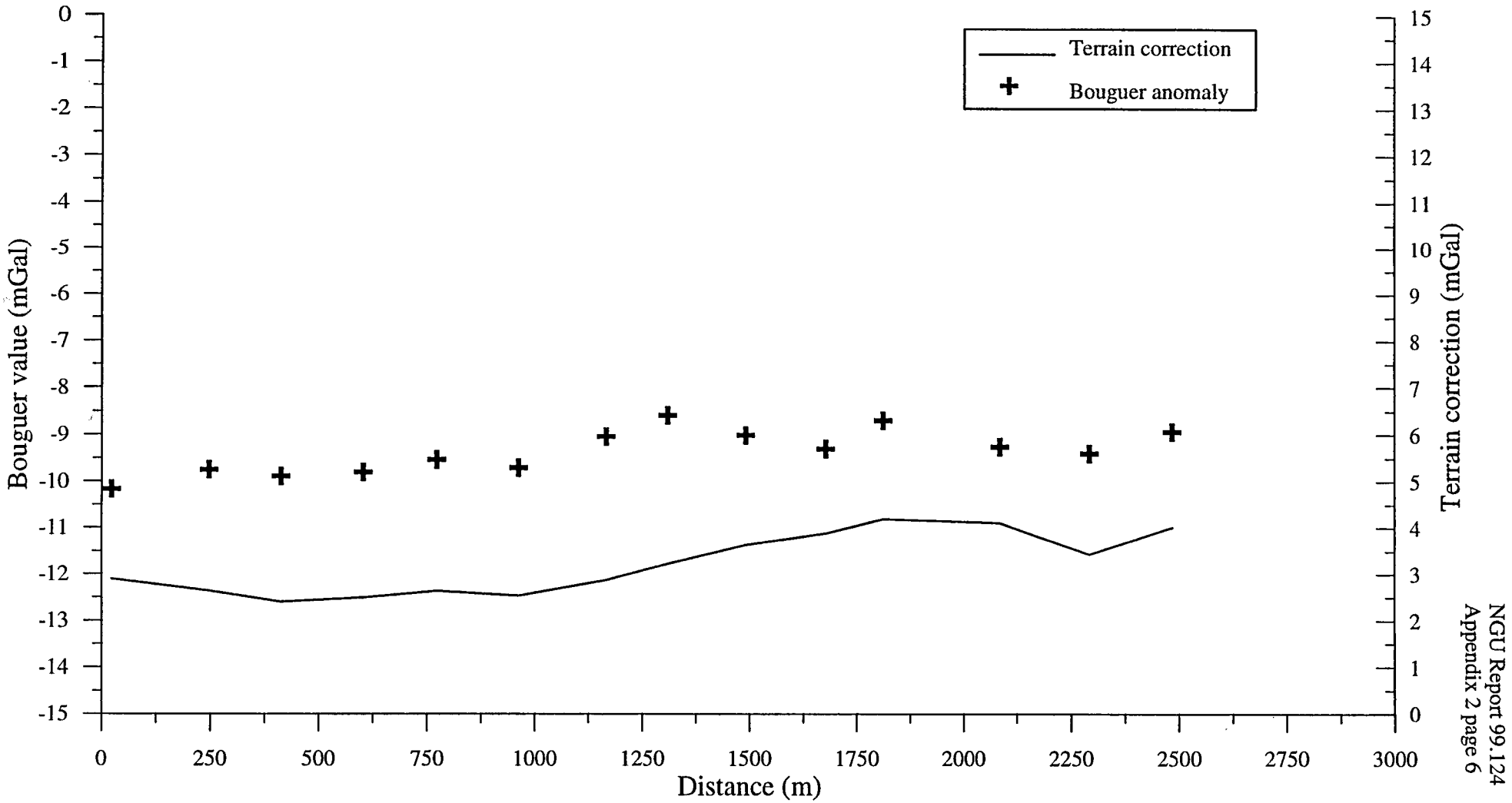
NAUSTDAL, gravity profile 14
Terrain correction and Bouguer anomaly values



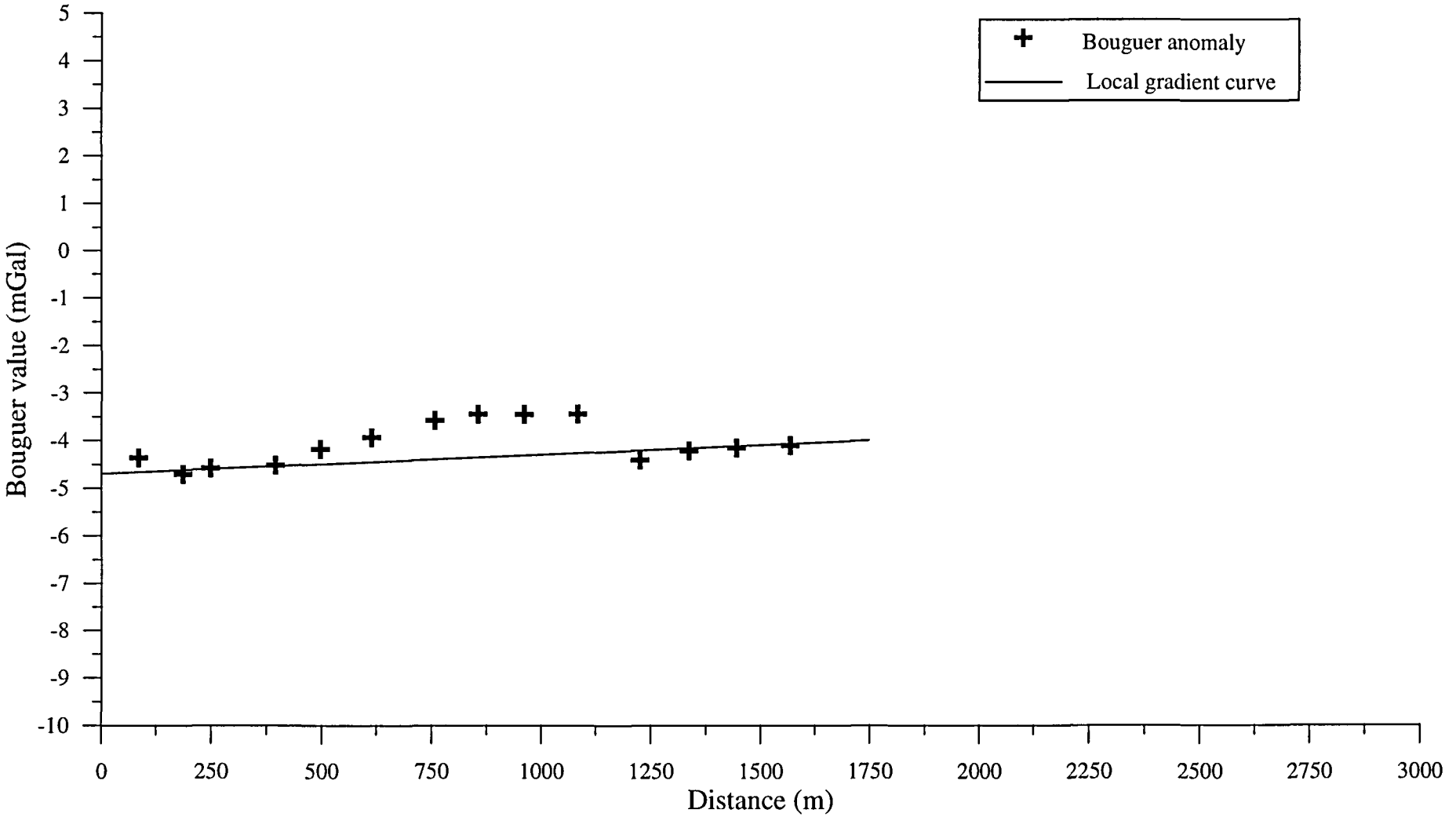
NAUSTDAL, gravity profile 15
Terrain correction and Bouguer anomaly values



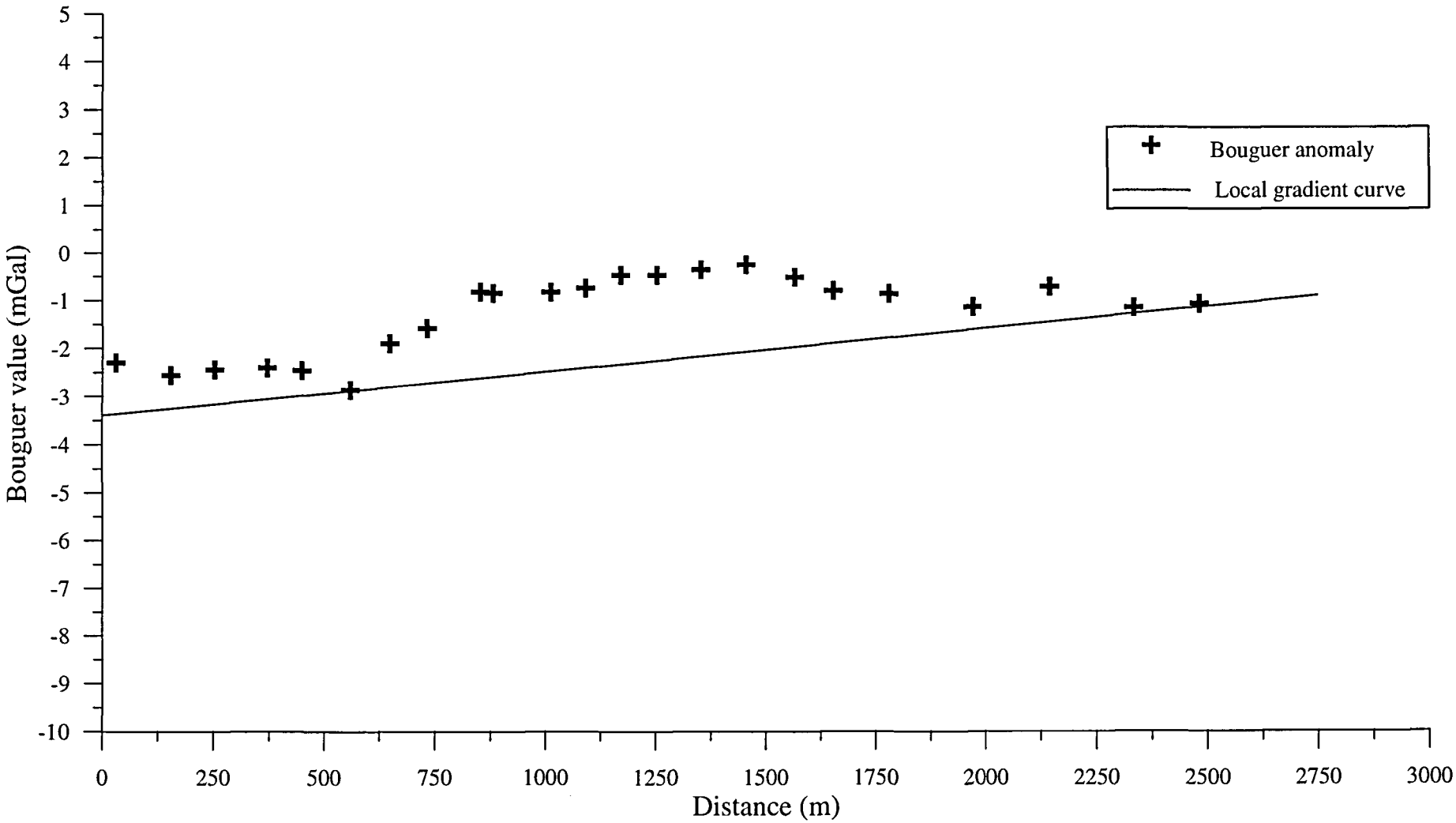
NAUSTDAL, gravity profile 16
Terrain correction and Bouguer anomaly values



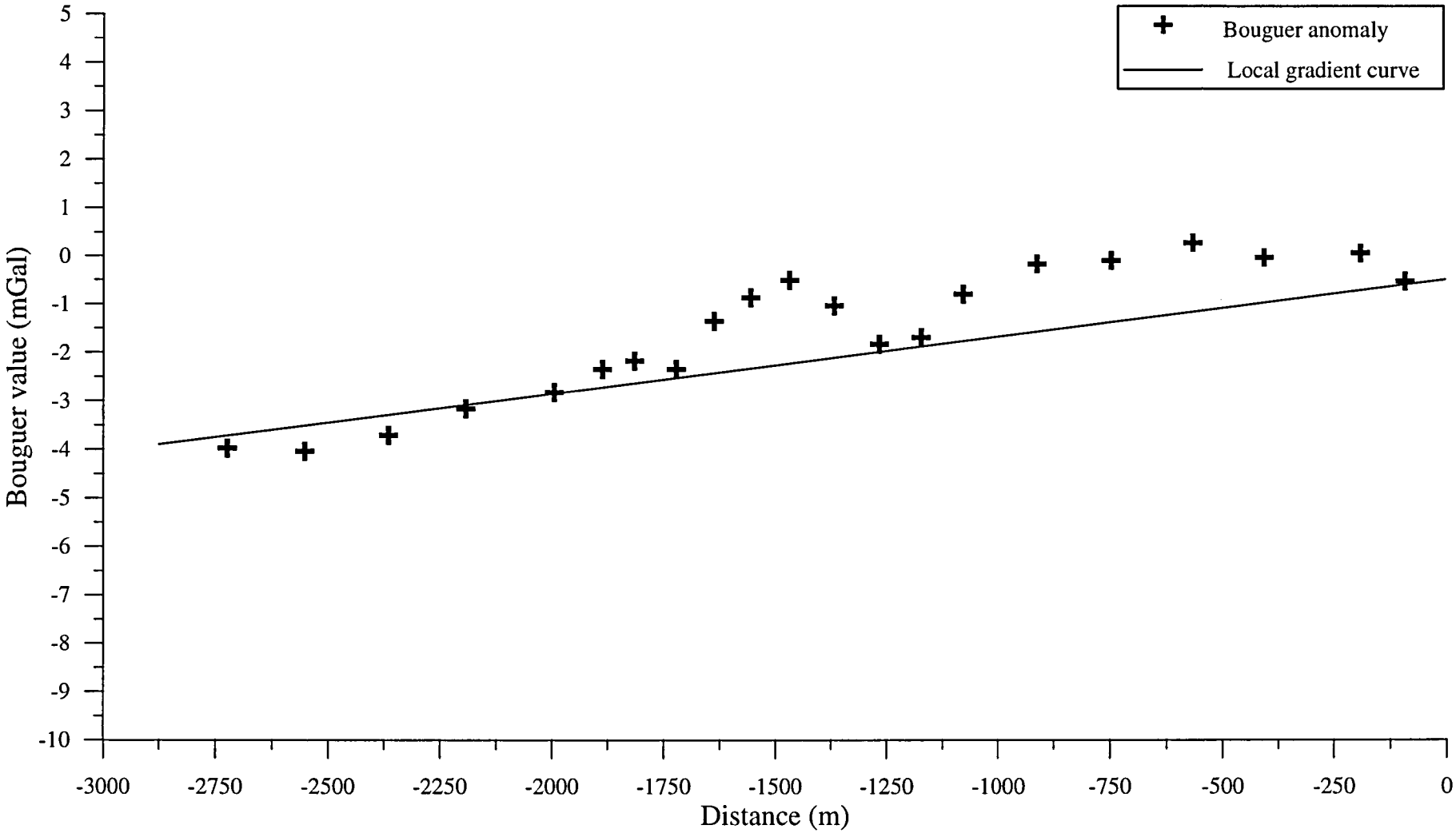
NAUSTDAL, gravity profile 11
Bouguer anomaly values and local gradient



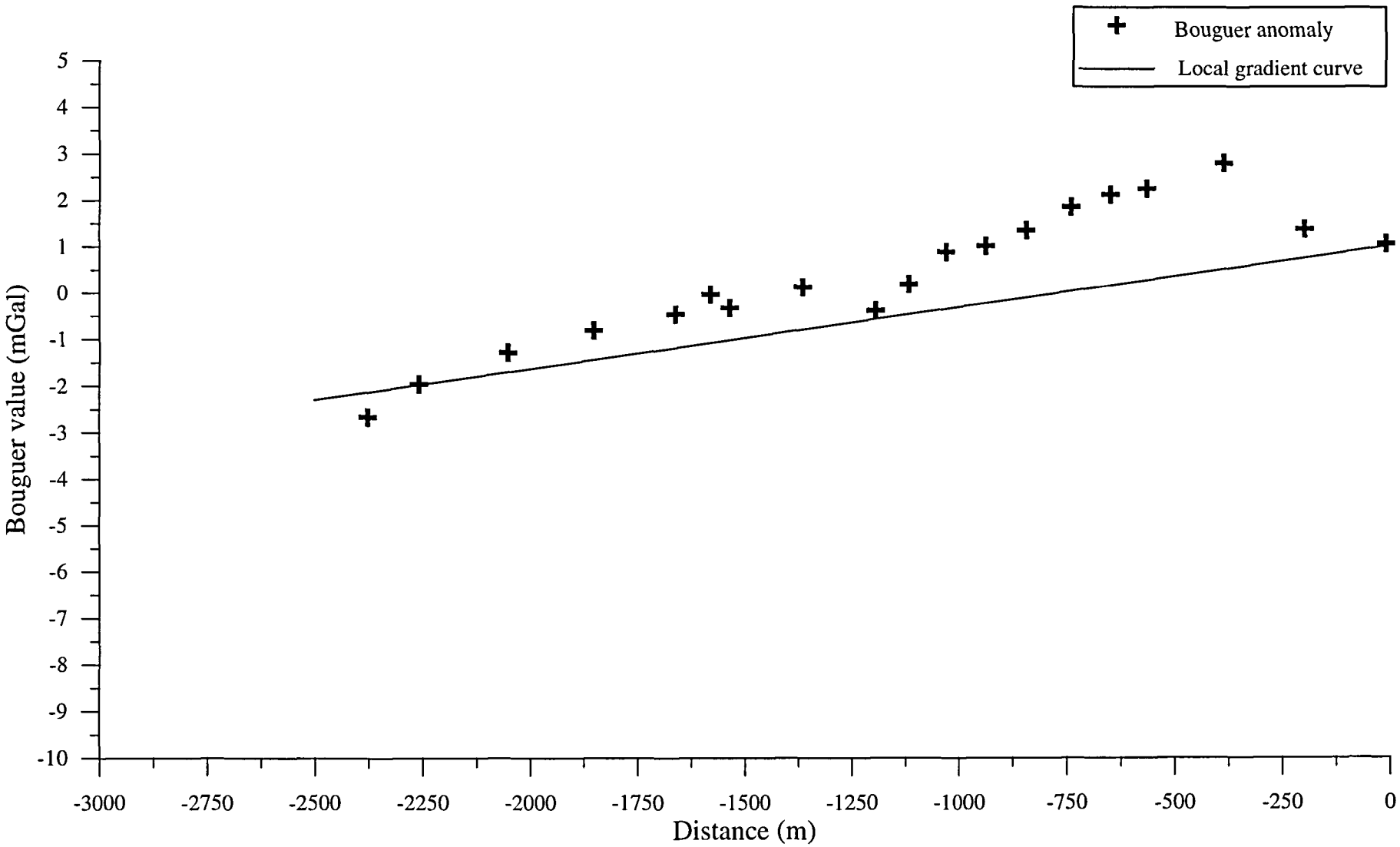
NAUSTDAL, gravity profile 12
Bouguer anomaly values and local gradient



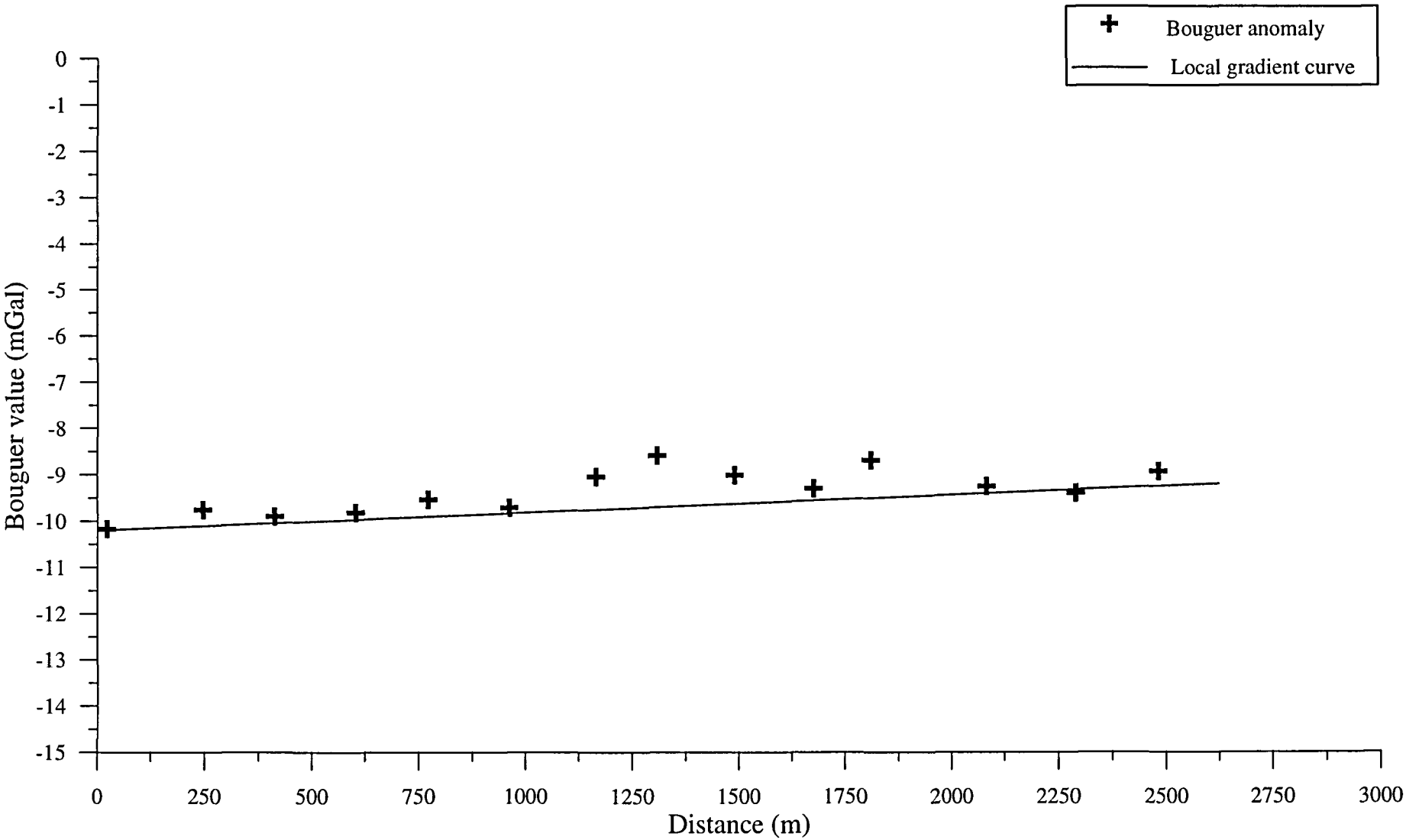
NAUSTDAL, gravity profile 13
Bouguer anomaly values and local gradient



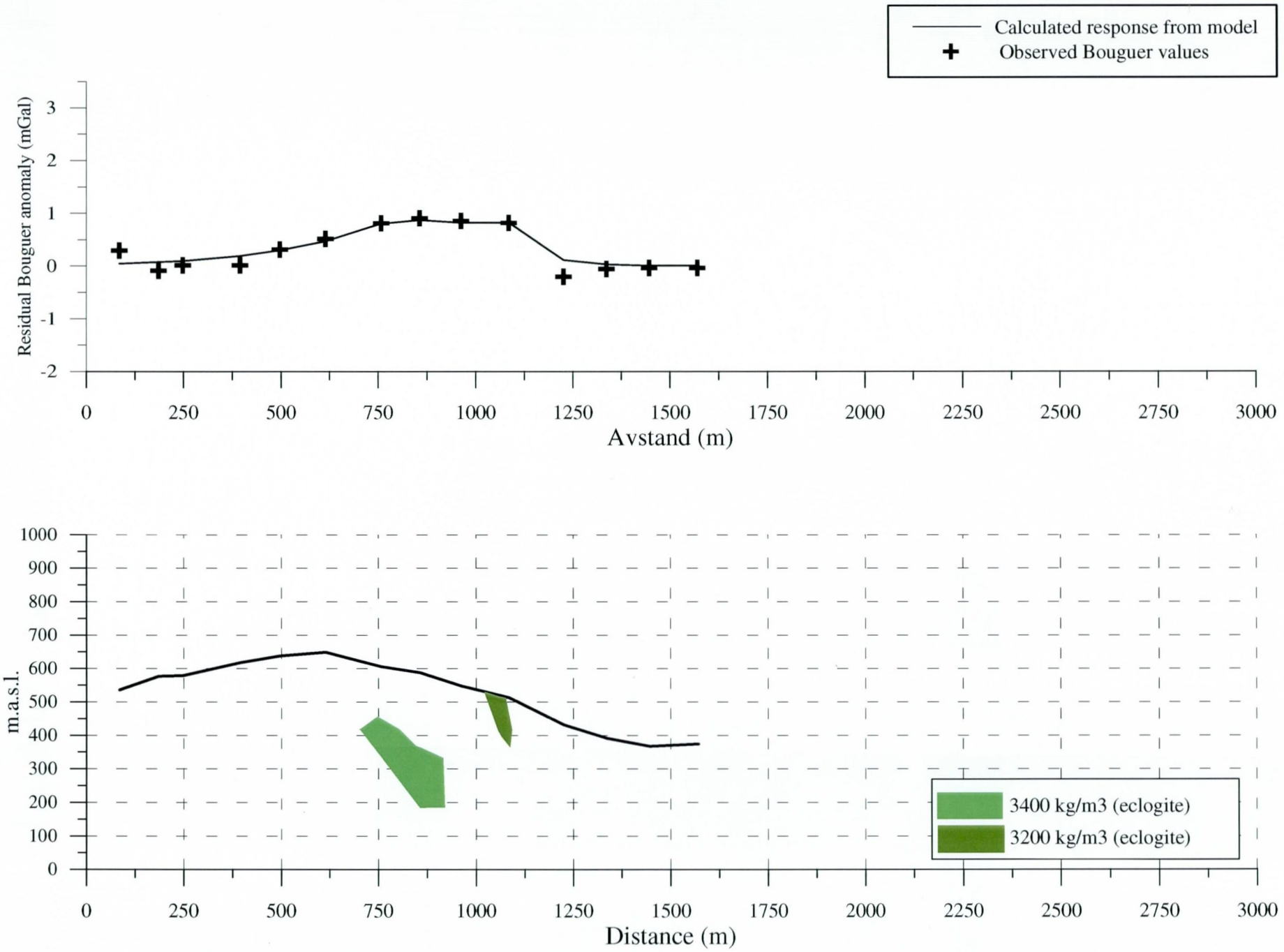
NAUSTDAL, gravity profile 14
Bouguer anomaly values and local gradient



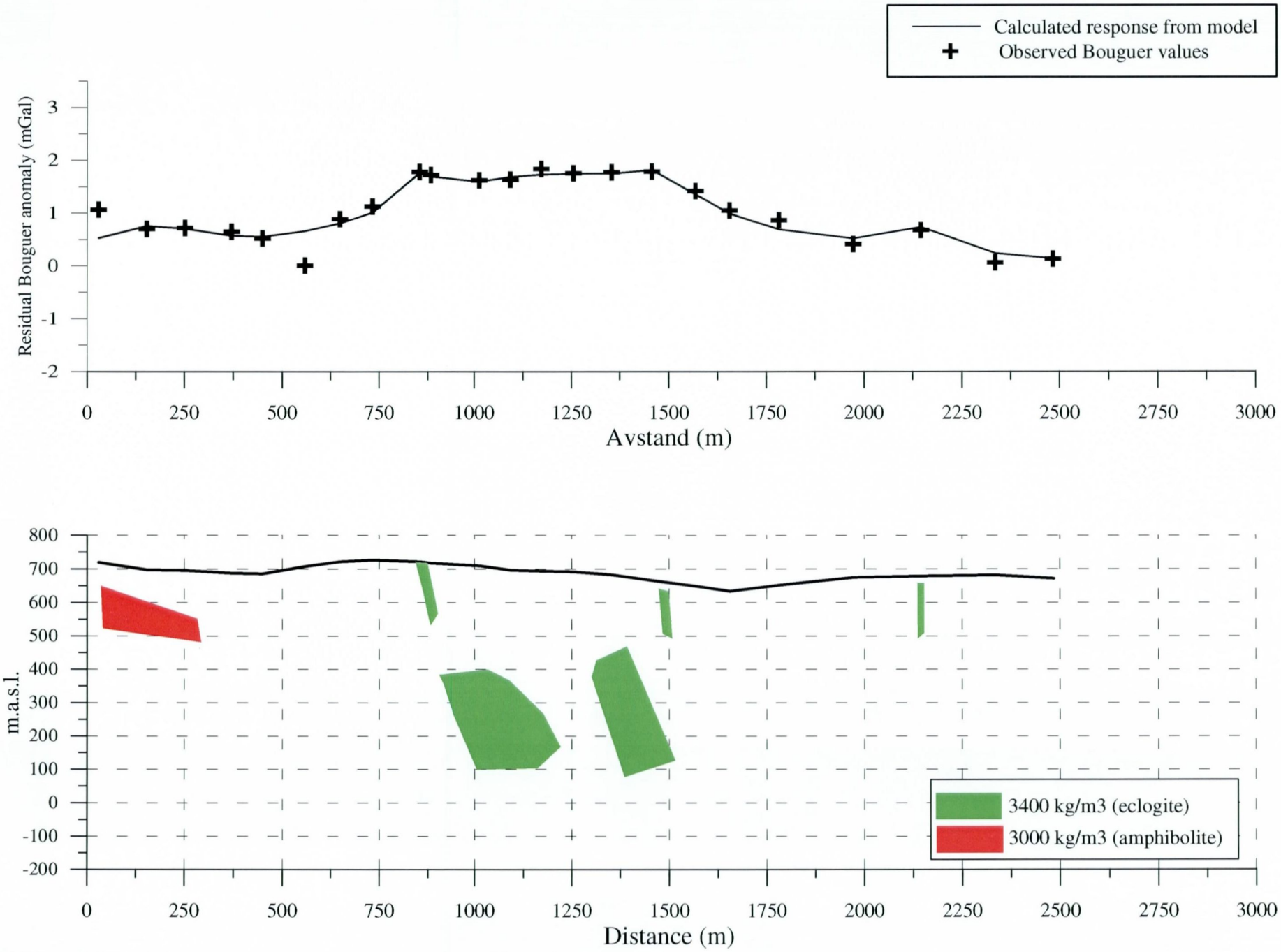
NAUSTDAL, gravity profile 16
Bouguer anomaly values and local gradient



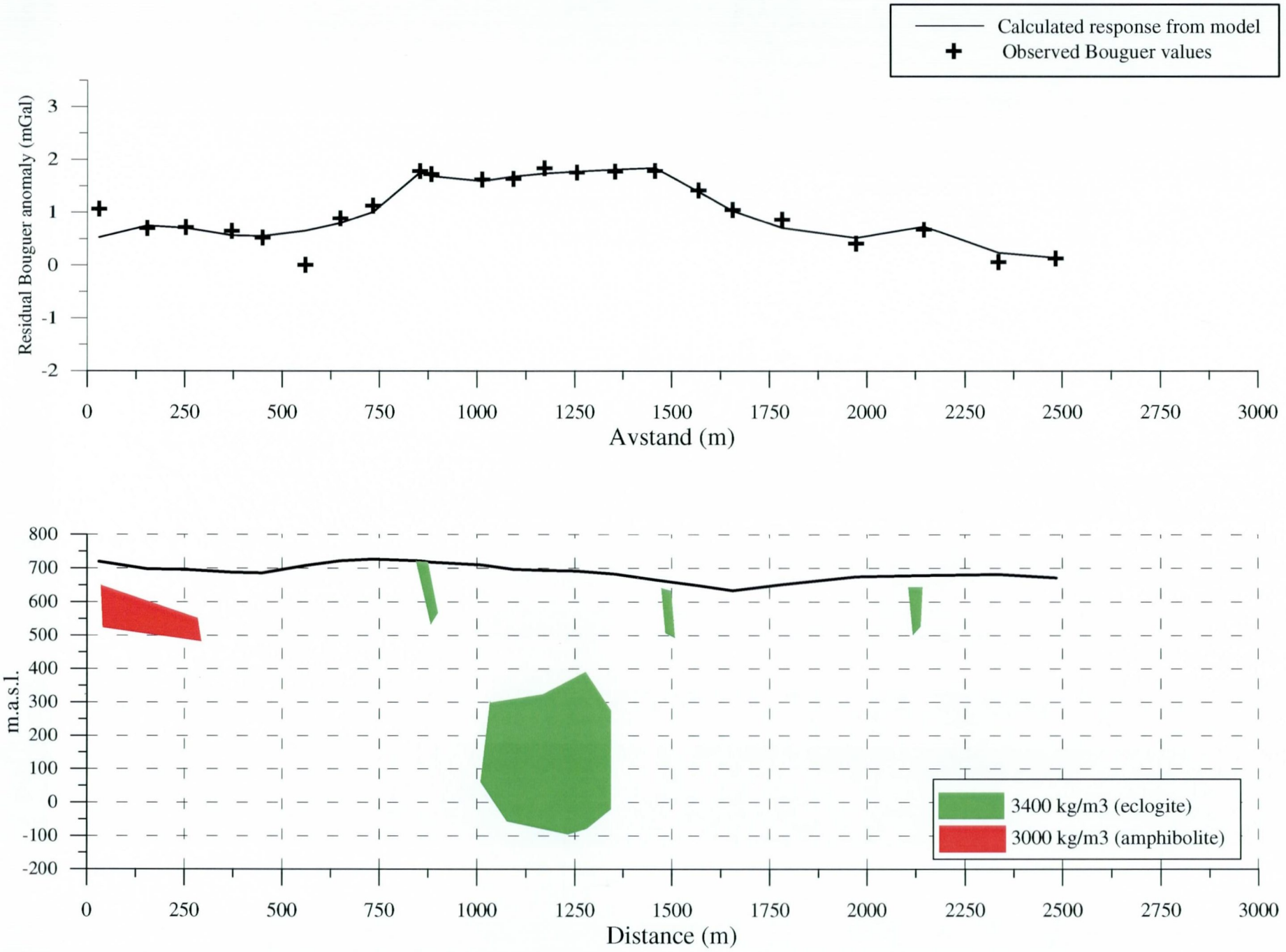
NAUSTDAL, gravity profile 11



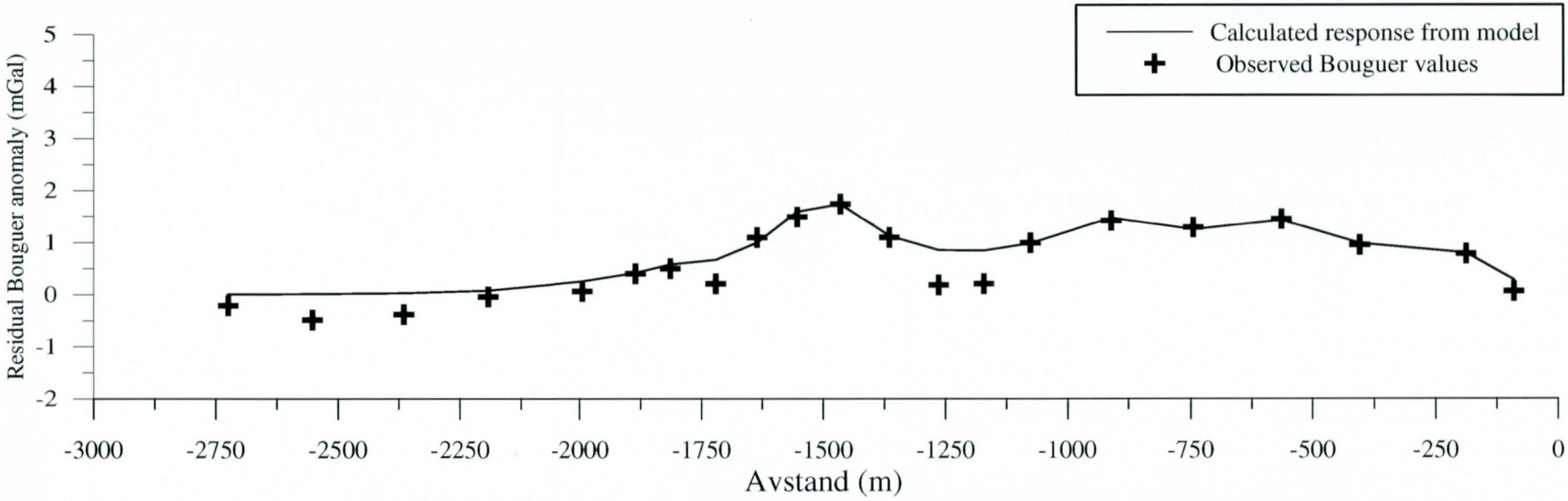
NAUSTDAL, gravity profile 12

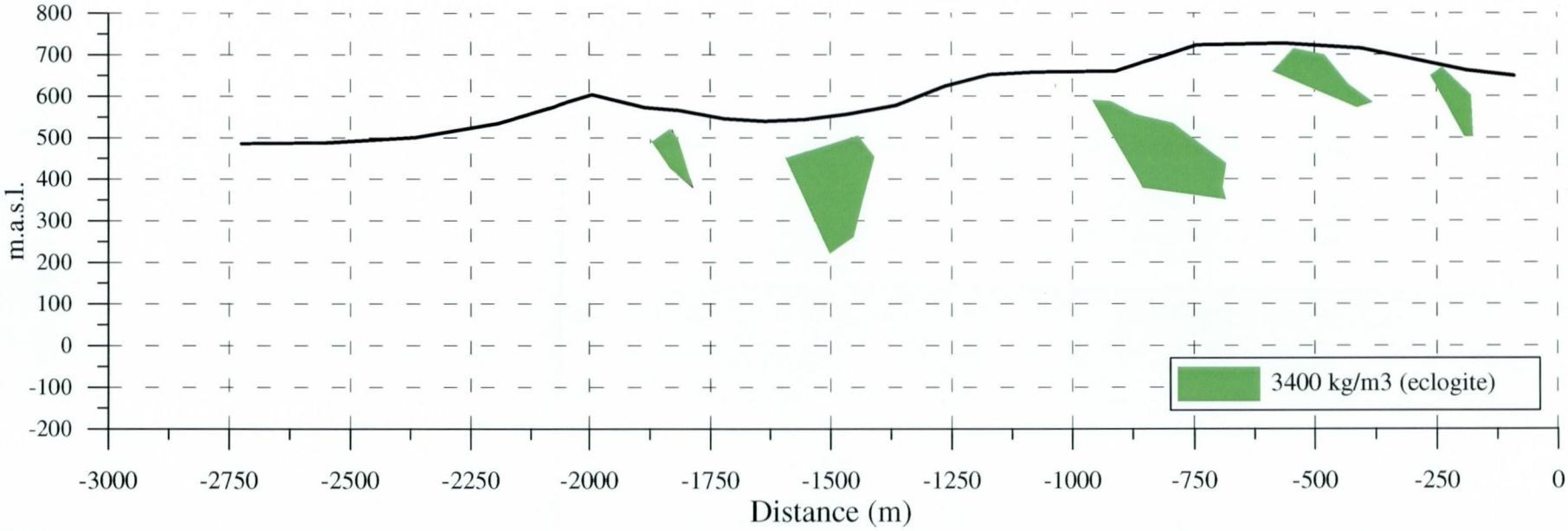


NAUSTDAL, gravity profile 12

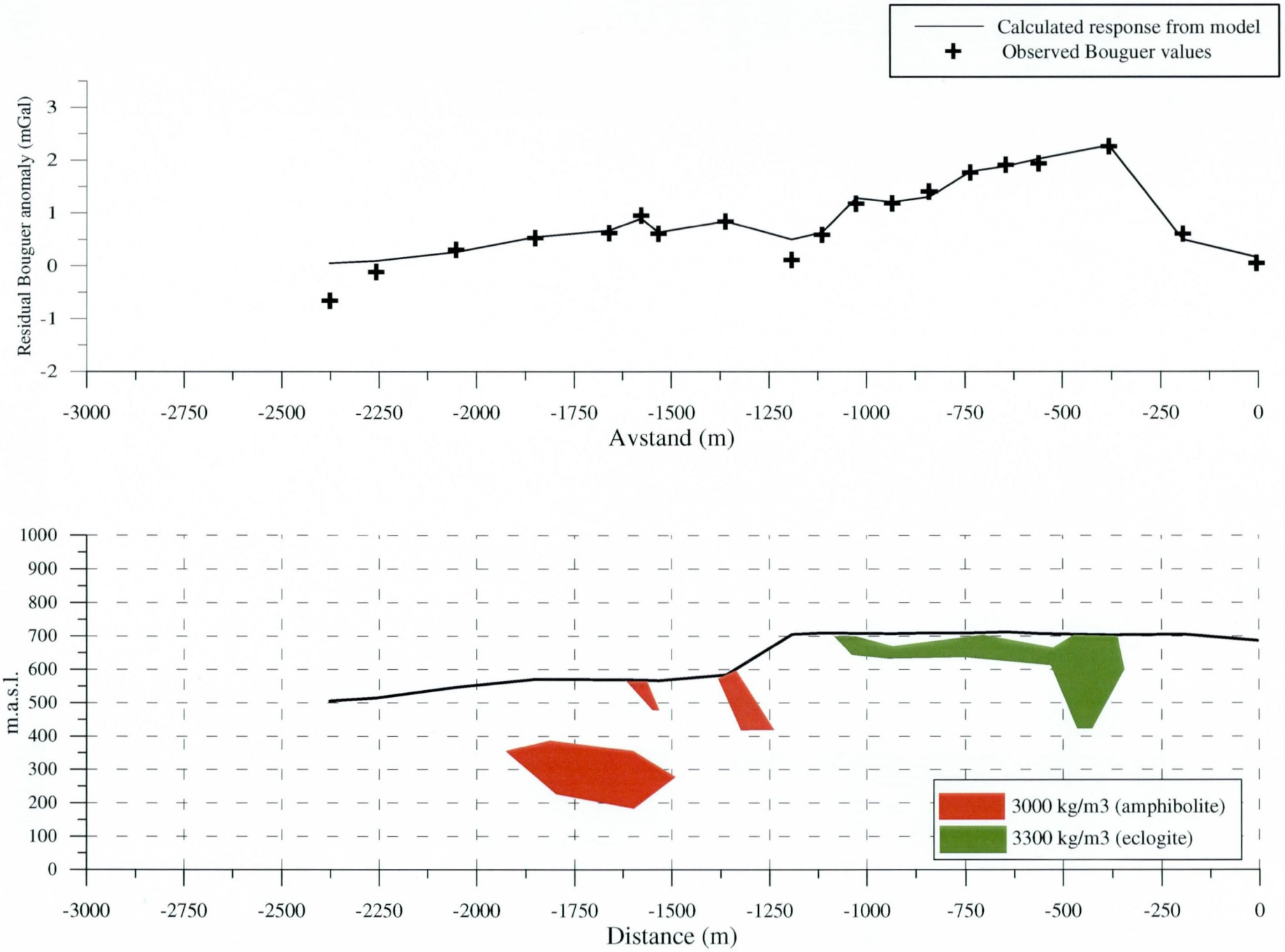


NAUSTDAL, gravity profile13

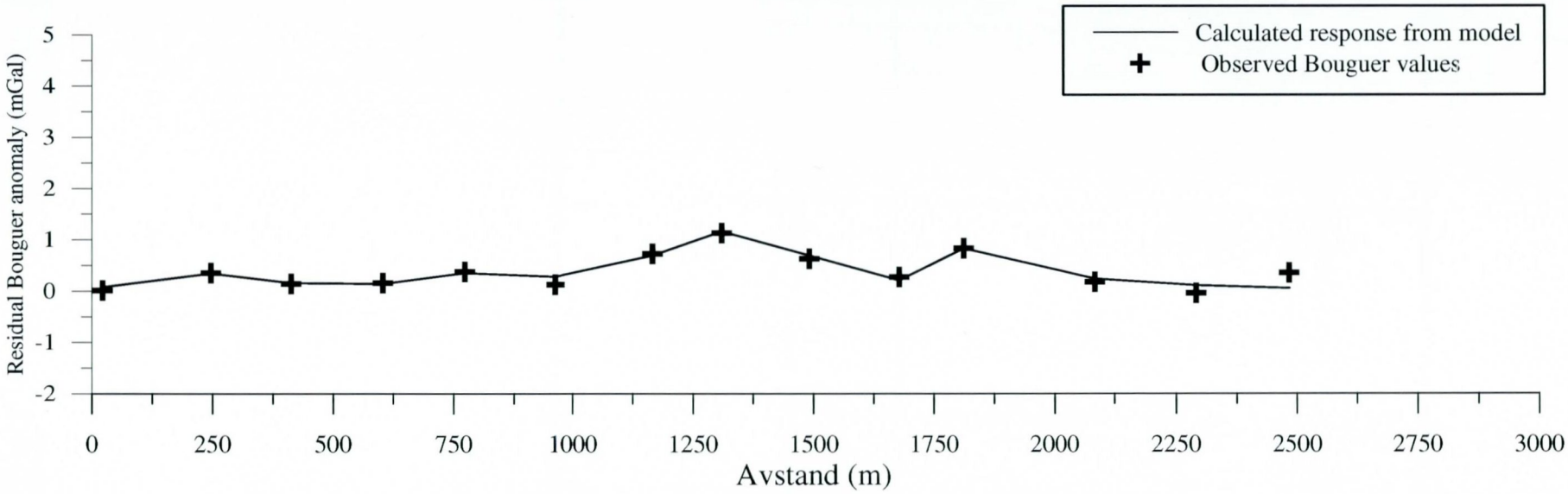


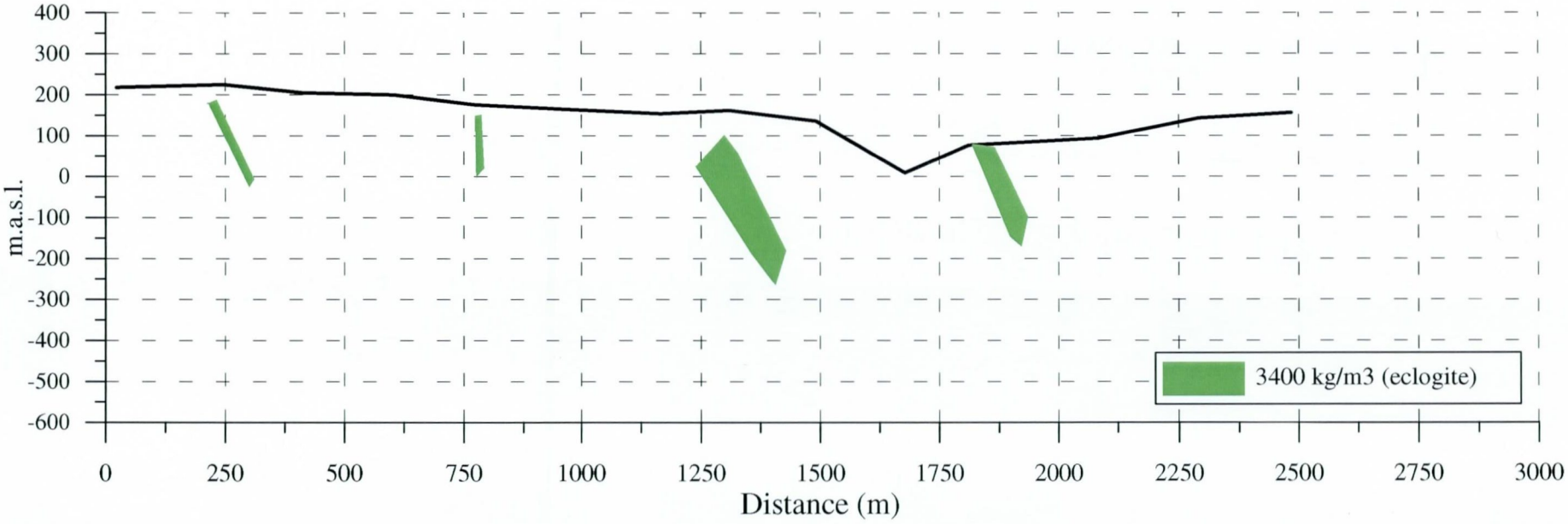


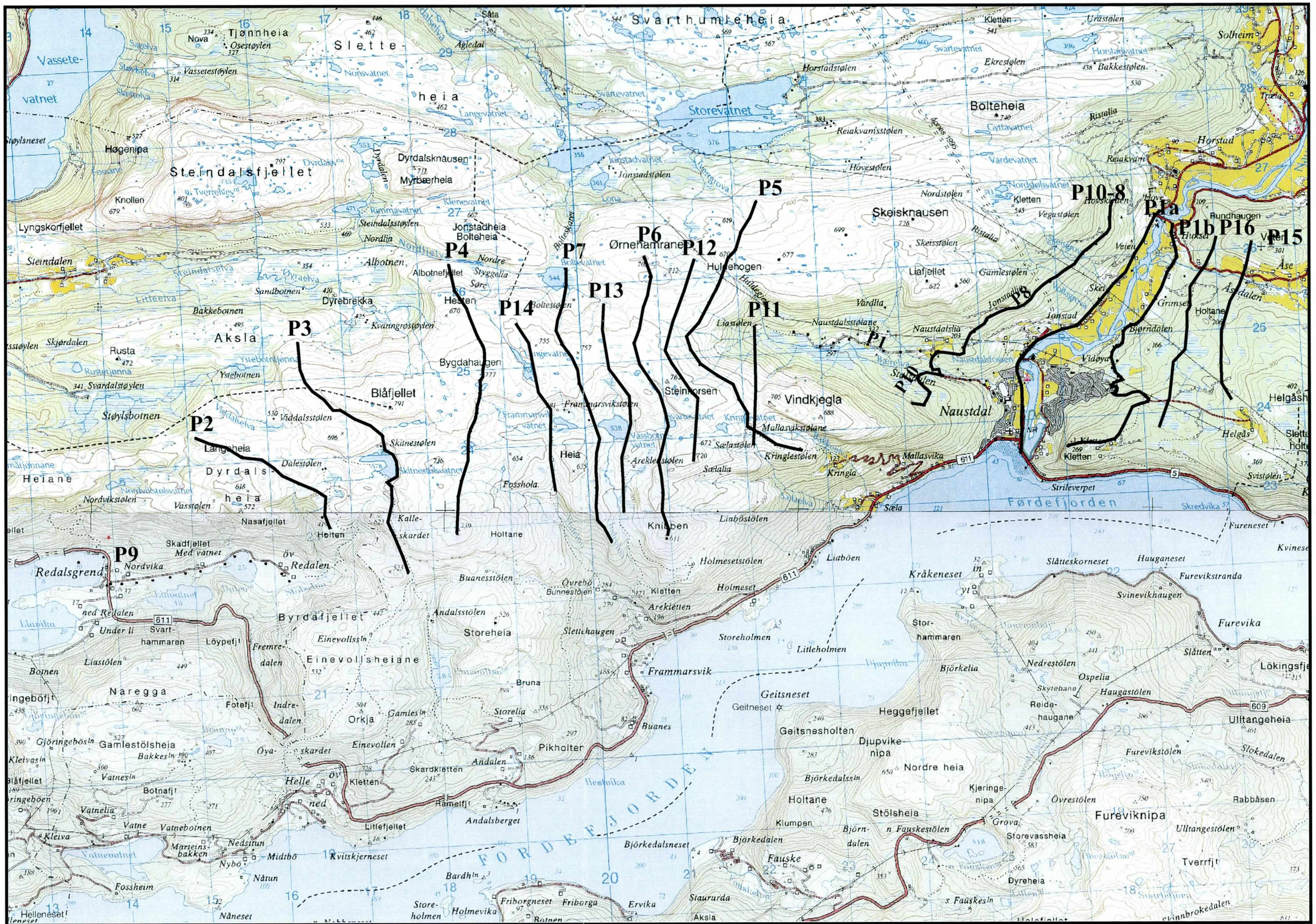
NAUSTDAL, gravity profile 14



NAUSTDAL, gravity profile16







P4 — Gravity profile

· Additional Gravity stations

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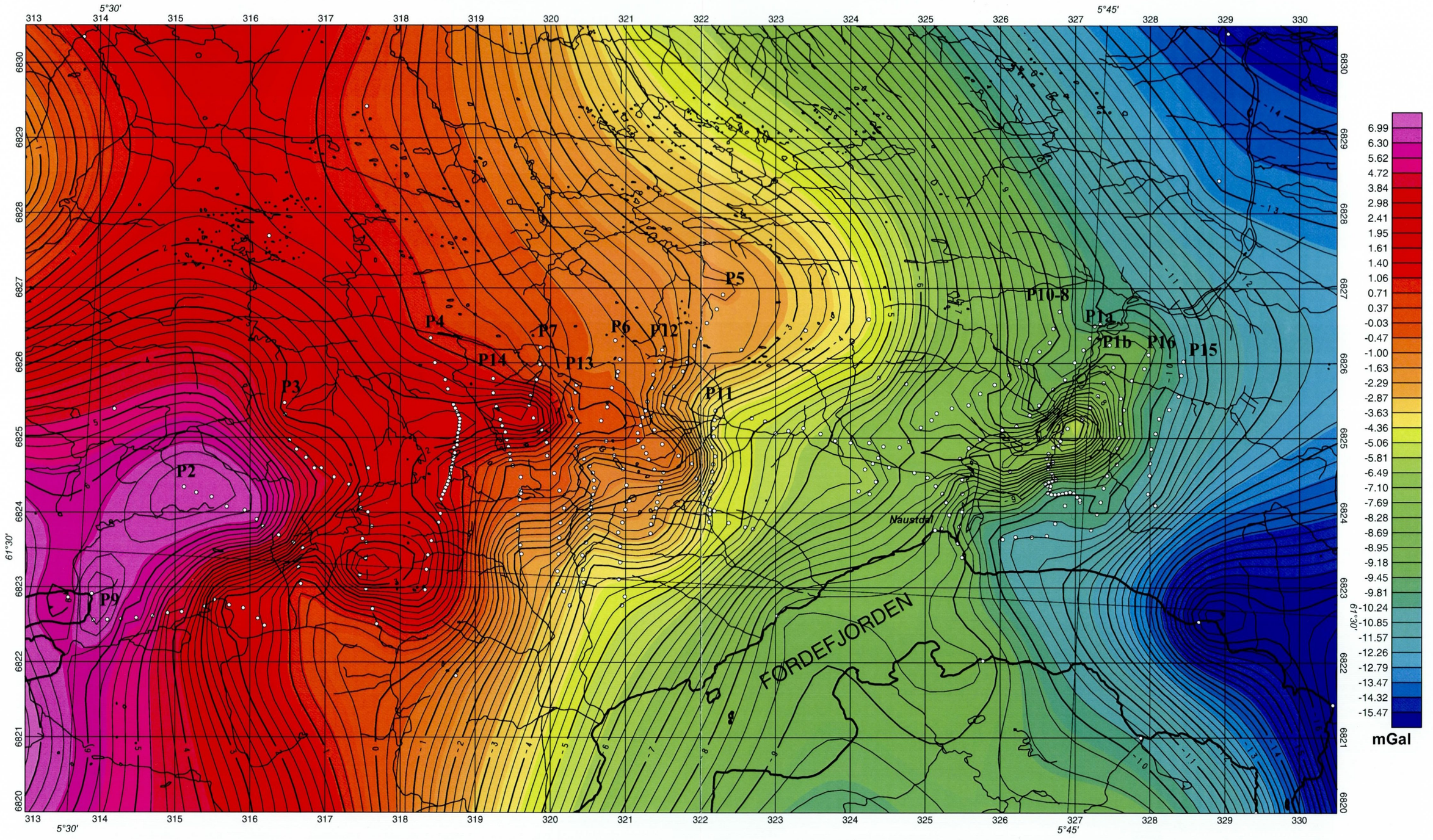
Geological Survey of Norway

GEOLOGICAL SURVEY OF NORWAY OVERVIEW MAP OF INVESTIGATED AREA NAUSTDAL NAUSTDAL, SOGN OG FJORDANE	SCALE 1:50 000	MEASURED ED, JG	Aug.-Sept. -99
		DRAW ED	Nov. -99
		TRAC	
		KFR KONF	
GEOLOGICAL SURVEY OF NORWAY TRONDHEIM	DRAW NO. 99.124-01	MAP SHEET 1217 IV, 1218 III	



Scale 1 : 50 000

0.5 0 0.5 1 1.5

kilometre

WGS 84 / UTM zone 32N

P4

Gravity profile

Bouguer Anomaly Map

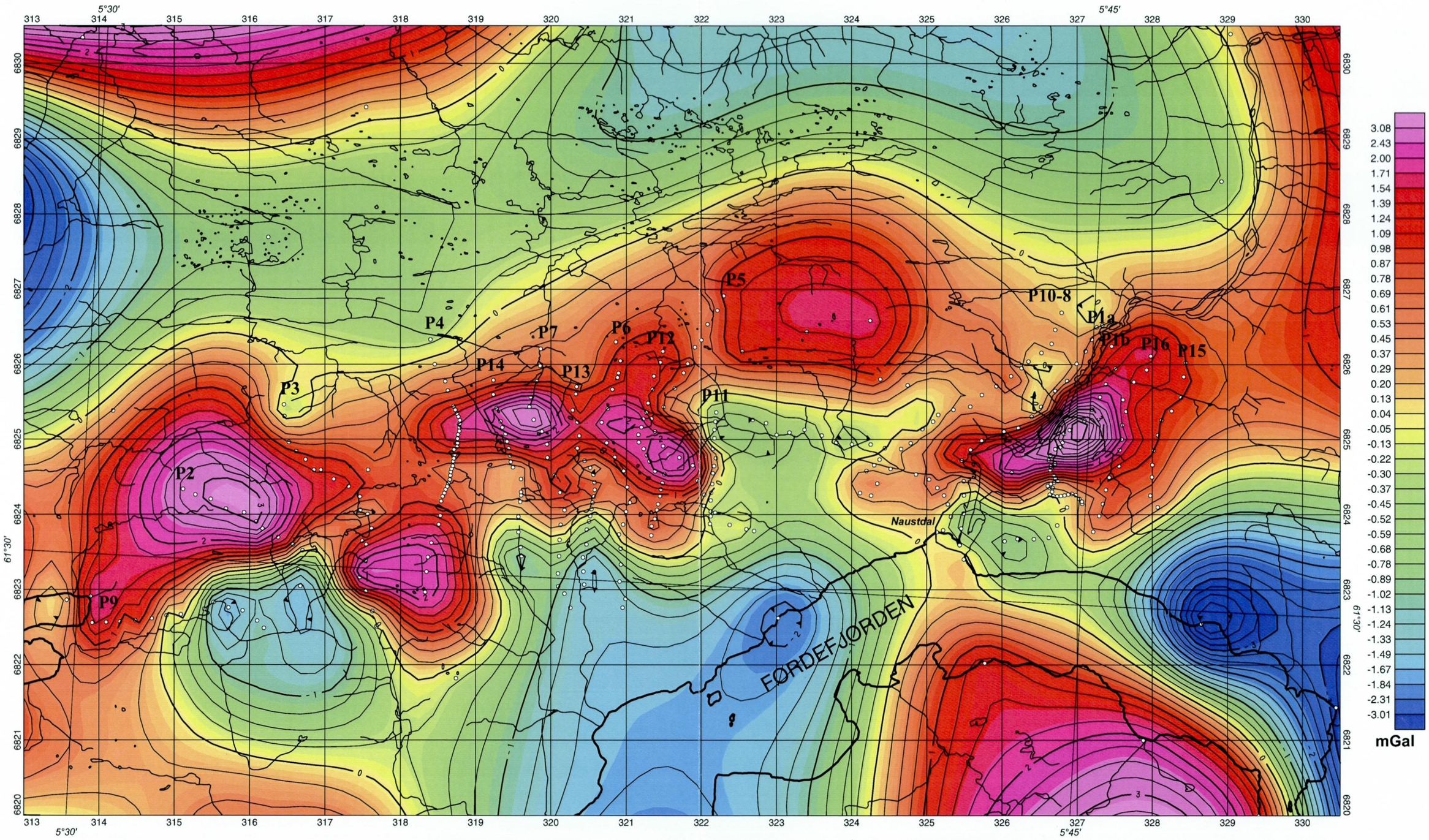
Naustdal

Map. no. 99.124-02

NGU

Norges geologiske undersøkelse

Geological Survey of Norway



Scale 1 : 50 000

0.5 0 0.5 1 1.5

kilometre

WGS 84 / UTM zone 32N

P4

Gravity profile

Residual Gravity Map

Naustdal

Map no. 99.124-03

Data description

A third order polynomial surface was fitted to the Bouguer grid values and then subtracted to produce the residual gravity grid.

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Geological Survey of Norway

B''
P5
A''
P10-8
P1a
P1b
P16
P15
P4
P7
P6
P12
P14
P13
P11
P3
P2
Naustdal
P9
B
A
Engebø
Helle
Førdefjorden
Fureviknipa

Mica schist

Granitic orthogneiss

Augengneiss

Granitic to granodioritic gneiss

Eclogite

Eclogite, amphibolite, metagabbro and grey gneiss

Geological map of the Førde area

Scale 1:50.000

Map number 99.124-04

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