R-07-67

Forsmark site investigation

Assessment of the validity of the rock domain model, version 1.2, based on the modelling of gravity and petrophysical data

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Abstract

This document reports the results gained by the geophysical modelling of rock domains based on gravity and petrophysical data, which is one of the activities performed within the site investigation work at Forsmark. The main objective with this activity is to assess the validity of the geological rock domain model version 1.2, and to identify discrepancies in the model that may indicate a need for revision of the model or a need for additional investigations.

The verification is carried out by comparing the calculated gravity model response, which takes account of the geological model, with a local gravity anomaly that represents the measured data. The model response is obtained from the three-dimensional geometry and the petrophysical data provided for each rock domain in the geological model. Due to model boundary conditions, the study is carried out in a smaller area within the regional model area. Gravity model responses are calculated in three stages; an initial model, a base model and a refined base model. The refined base model is preferred and is used for comparison purposes.

In general, there is a good agreement between the refined base model that makes use of the rock domain model, version 1.2 and the measured gravity data, not least where it concerns the depth extension of the critical rock domain RFM029. The most significant discrepancy occurs in the area extending from the SFR office to the SFR underground facility and further to the northwest. It is speculated that this discrepancy is caused by a combination of an overestimation of the volume of gabbro (RFM016) that plunges towards the southeast in the rock domain model, and an underestimation of the volume of occurrence of pegmatite and pegmatitic granite that are known to be present and occur as larger bodies around SFR. Other discrepancies are noted in rock domain RFM022, which is considered to be overestimated in the rock domain model, version 1.2, and in rock domain RFM017, where the gravity model response shows a somewhat different extension of the gravity anomaly (Z-shape) than the original data indicates. A small mass deficiency is also apparent in RFM017, indicating that the rock domain is slightly underestimated in density and/or volume compared to rock domain RFM029. In the south-eastern part of rock domain RFM023, the occurrence of less dense, subordinate granitic rocks has not been sufficiently accounted for. All these rock domains are situated more or less completely outside the local model volume.

The modelling work carried out here is strongly restricted by the paucity of quantitative data that bear on the volumetric proportions of subordinate rock types in each domain. This problem has been addressed to some extent by the development of alternative models that do not solely take account of the average density of the dominant rock type.

Finally, the strong gravity anomaly (5–7 mgal) that is situated c 3 km northwest of the Forsmark nuclear power plant needs to be mentioned, even though it is located outside the regional model area. A continuation and enlargement of the diorite-gabbro domain RFM025 towards the northwest, including also a higher density corresponding to rocks with more mafic or even ultramafic composition, may explain this gravity high. However, the shape and wavelength of the anomaly, and the fact that iron oxide mineralisation is known in the area, imply that an association to an metallic but non-magnetic ore can not be ruled out.

Sammanfattning

Denna rapport redovisar resultat från geofysisk modellering av gravimetriska och petrofysiska data som en del av platsundersökningarna i Forsmark. Syftet är att värdera den geologiska modellen version 1.2 genom att identifiera osäkerheter vilka kan innebära behov av revidering av modellen eller behov av ytterligare undersökningar.

Utvärderingen har genomförts genom att jämföra modellens gravimetriska respons med en lokalanomali vilken representerar de faktiskt uppmätta tyngdkraftsdata. Modellresponsen erhålls från modellens 3-dimensionella geometri samt petrofysiska data från de olika bergdomänerna i den geologiska modellen. Genom gränsvillkor i modelleringen begränsas studien till ett mindre område inom det regionala modellområdet. Gravimetermodelleringen har genomförts i tre steg; med en initialmodell, med en basmodell samt med en förfinad basmodell. I vart och ett av stegen har avvikelser mellan modellresponsen och uppmätta data noterats. Den förfinade basmodellen är att föredra och har använts vidare för jämförande studier.

Allmänt är överensstämmelsen god mellan den förfinade basmodellen och uppmätta data, inte minst i utbredningen av den viktiga bergdomänen RFM029 mot djupet. Den mest betydande avvikelsen har identifierats i området från SFR kontoret till SFR förvaret och vidare mot nordväst. Det är möjligt att denna avvikelse orsakas av en kombination av att volymen av domän RFM016 (gabbro), vilken fältstupar mot sydost, har överskattats samt att förekomsten av pegmatit och pegmatitgranit är underskattad i området. Andra avvikelser som noterats är domän RFM022, vilken bedöms vara överskattad i den geologiska modellen, version 1.2. I domän RFM017 visar modellresponsen en annan utbredning och form (Z-form) än vad uppmätta data indikerar. Ett mindre massunderskott för domän RFM017 indikerar också att den är underskattad i densitet och/eller volym jämfört med domän RFM029. Sydöstra delen av RFM023 har ett massöverskott som indikerar att de underordnade granitiska bergarter med lägre densitet som förekommer i området kan vara underskattade i volym. Alla dessa domäner ligger mer eller mindre helt utanför den lokala modellvolymen.

Den geofysiska modellering som utförts begränsas av bristen på kvantitativa data som beskriver mängden av och proportionen mellan olika underordnade bergarter i varje domän. Problemet hanteras till viss del genom alternativa modeller där modelldensiteten varieras utanför medeldensiteten för den dominerande bergarten.

Slutligen har ett markant massöverskott (5–7 mgal) identifierats ca 3 km nordväst om Forsmarksverken. Möjligen kan anomalin förklaras med att en utökning av diorit-gabbro domänen RFM025 alternativt också med mer mafisk eller ultramafiska inslag i denna domän. På grund av anomalins form och våglängd, samt det faktum att järnoxid-mineraliseringar är kända i området, kan en koppling till en metallisk men omagnetisk malm inte uteslutas.

Contents

1 Introduction

This document reports the results gained by the geophysical modelling of rock domains based on gravity and petrophysical data, which is one of the activities performed within the site investigation at Forsmark. Activity plan and method descriptions are SKB's internal controlling documents. The work was carried out in accordance with activity plan AP PF 400-05-064 (Table 1-1). No method description exists specifically for quantitative geophysical modelling. However, /1/ gives a general guidance for handling geometries in geological modelling.

The site investigations provide basic data for three dimensional modelling of the different geological units in the area. A first version, version 1.1, was presented in /2/ and has continuously been developed and refined to the ongoing, current stage 2.2 /3, 4, 5/. The version used in this activity is version 1.2 /3/.

Geophysical information, in particular airborne magnetic data, have assisted in the construction of the bedrock geological map at the surface in the Forsmark area /3, 6/, while the extension of rock volumes to depth have been based on geological data from the surface and from drill holes. However, it was judged that the prerequisites for geophysical three-dimensional modelling are good, with regional gravity data /7/, airborne geophysics /8, 9, 10/ and petrophysical data from surface and drill holes /11, 12, 13/. With this strategy in mind, the validity of the version 1.2 geological model for rock domains is addressed in this report using three-dimensional modelling of some of the geophysical data. The work has been carried out in different time periods from November 2005 until July 2007 and the activity covers the regional model area at Forsmark (Figure 1-1).

Table 1-1. Controlling documents for the performance of the activity.

Activity plan	Number	Version
Modellering av bergvolymer utifrån tyngdkraftsdata och flygmagnetiska data	AP PF 400-05-064	1.01
Method descriptions	**Number**	**Version**
No method description but see /1/		

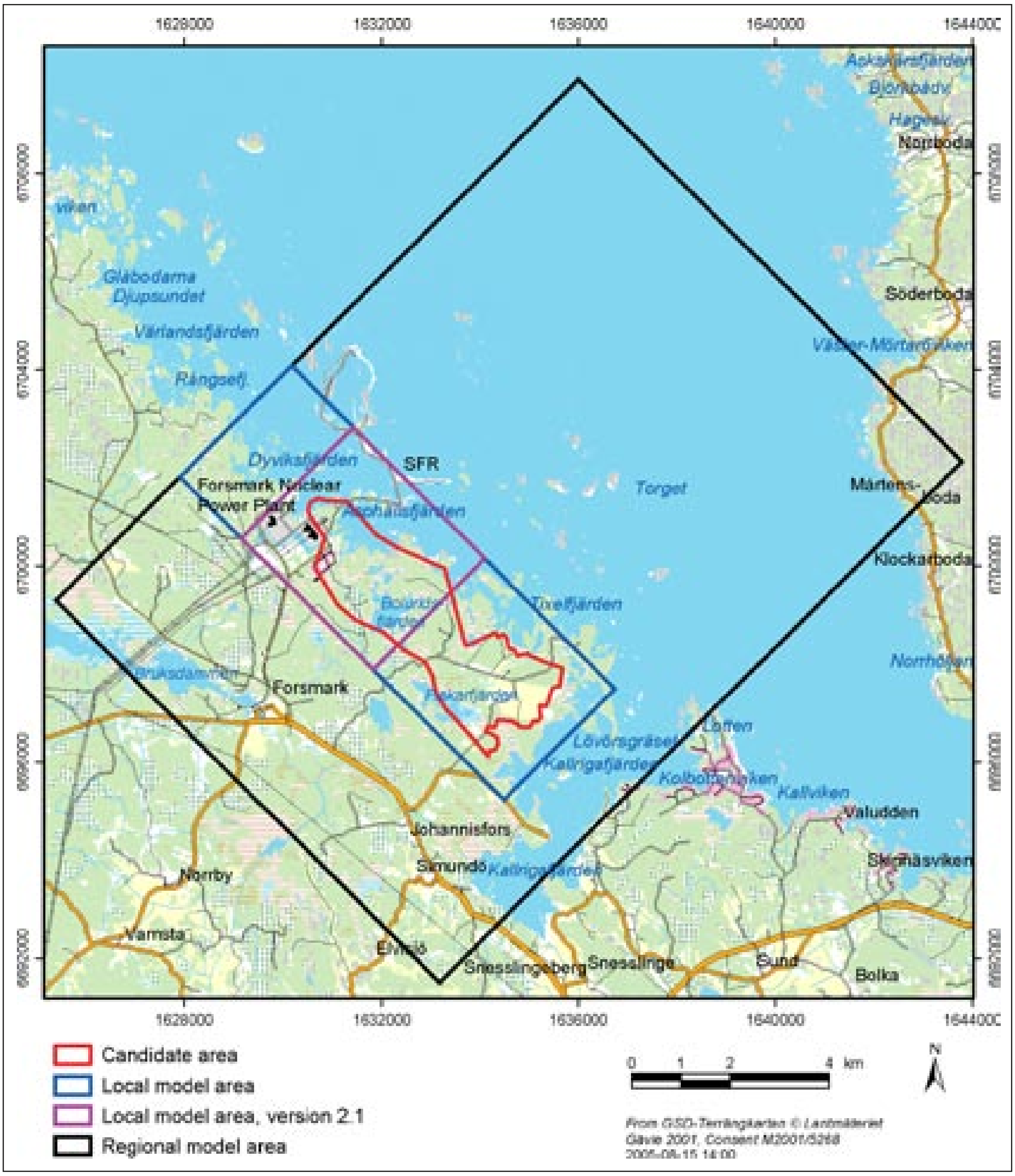


Figure 1-1. *The Forsmark candidate area and the regional and local model areas in preliminary site descriptive models. Figure from /4/. The regional model area is the same as that used in all model versions and stages. The local model area defined in version 1.1 (blue line) surrounds the Forsmark candidate area (red line). The local model area used in model stage 2.1 (and stage 2.2) is outlined in magenta.*

2 Objective and scope

The main objective with the activity is to assess the validity of the geological rock domain model version 1.2 /3/, and to identify discrepancies in the model that may indicate a need for revision of the model or a need for additional investigations.

This activity has been carried out by comparing the geophysical response calculated from the rock domain model with the geophysical anomaly defined by the actual measured data. The model response is obtained from the three dimensional geometry model version 1.2 /3/ and the petrophysical data given for each rock domain in the geological model /11, 12, 13, 16/. Information on the volumetric proportions of rock types for two rock domains has been collected from model version 1.2 /3/ and model stage 2.2 /5/. The conditions in the local model volume and the depth extension of the dominant rock type metagranite in this volume are of special interest in the study. The geophysical modelling work has focused solely on gravity data with support from petrophysical data. Modelling of airborne magnetic data was not completed here. However, such modelling could be carried out using magnetic susceptibility properties for individual rock domains.

3 Equipment

3.1 Description of interpretation tools

The processing, modelling and reporting included the use of the following specialized software:

Surfer 8 (Golden software); basic processing and interpolation.

Oasis Montaj 5.0 (Geosoft Inc); basic processing, filtering and transformations.

Geomatica 10 (PCI Inc); image analysis and interpretation.

MapInfo Professional 8 (Mapinfo Corp.); GIS, map handling and figures.

Discover 8 (Encom Technology Pty Ltd); GIS, map handling and figures.

Modelvision version 7.1 (Encom Technology Pty Ltd); gravity and magnetic modelling.

Microstation version 8 (Bentley system Inc); CAD 3-D handling.

4 Execution

4.1 General

The work initially involved the preparation of gravity and petrophysical data as well as conversion of the geological rock domain model to a suitable format for the gravity modelling work. After preparation work, the geological rock domain model and gravity data were imported into the modelling software. Each rock domain in the geological model was then assigned a density value based on available petrophysical data. Gravity model responses were then calculated in three stages; an initial model, a base model and a refined base model. During each stage, discrepancies between the model responses and the measured data were noted.

In the initial model, the density is based solely on the dominant rock type within each rock domain.

The base model involves a more realistic gravity response in which the input density values are more carefully adapted to the actual density values occurring within each rock domain, and also by taking some account of subordinate rock types and mixing between different rock types in a domain.

In the refined base model, the modelling responses are compared with the measured gravity data and, by continuous iterations with adjustments of the rock domain densities, differences are minimized. The input density values are selected on the basis of statistical deviations in the petrophysical data in combination with the mixing of dominant and subordinate rock types.

4.2 Data handling, processing, analysis and interpretation

4.2.1 Petrophysical data

The petrophysical data used in this activity are compiled using data from the regional rock domain model, version 1.2 (Table 4-1) /3/, supplemented with data from /13/ and /16/. The petrophysical data has also been assign to individual rock domains by the use of GIS, simply by selecting all petrophysical sample locations located within an individual rock domain (Figure 4-1). A table with the petrophysical data /5/ and the adherent rock domain, version 1.2 /3/, is presented in Appendix 1.

Table 4-1. Physical properties of the different rock types at the Forsmark site as presented in /3, Table 5-3/. The parameter values in this table are based on surface data in /11/ and data from boreholes KFM01A, KFM02A, KFM03A and KFM03B in /12/. The code classification of each sample is based on that assigned during the surface or borehole mapping.

Code (SKB)	Composition (and grain size) Name (IUGS/SGU)	Physical properties Density (kg/m^3)		Porosity (%)		Magnetic susceptibility (SI units)		Electrical resistivity in fresh water (ohm m)		N (No. of samples)
		Range	Mean/Std	Range	Mean/Std	Range	Geometric mean/ Std above mean/ Std below mean	Range	Geometric mean/Std above mean/Std below mean	
103076	Felsic to intermediate volcanic rock, metamorphic	2,648–2,946	2,732/79	0.20–0.62	0.37/0.11	0.00006–0.24000	0.00235/ 0.04163/ 0.00222	1,725–81,878	14,374/ 22,146/ 8,716	19
106001	Sedimentary rock, meta-morphic, veined to migmatitic	2,691		0.48		0.00270		10,888		1
108019	Calc-silicate rock (skarn)	No data available								
109010	Pyrite-pyrrhotite-chalcopyrite-sphalerite mineralisation	No data available								
109014	Magnetite mineralisation associated with calc-silicate rock	4,130–4,225		1.24–1.47		0.12220–0.12400		168–324		2
01004	Ultramafic rock (olivine-hornblende pyroxenite)	3,045		1.04		0.04572		52		1
102017	Amphibolite	2,928–3,048	2,988/60	0.24–0.32	0.29/0.04	0.00067–0.00071	0.00069/ 0.00002/ 0.00002	11,211–38,904	22,062/ 15,840/ 9,220	3 (5 for elec. resis.)
101033	Diorite, quartz diorite and gabbro, metamorphic	2,738–3,120	2,934/100	0.25–0.54	0.37/0.07	0.00036–0.05592	0.00293/ 0.01914/ 0.00254	5,412–34,227	15,315/ 12,575/ 6,905	14
101054	Tonalite to granodiorite, metamorphic	2,674–2,831	2,737/43	0.31–0.53	0.40/0.07	0.00020–0.03507	0.00185/ 0.01049/ 0.00157	5,921–25,249	14,380/ 6,715/ 4,578	21 (22 for elec. resis.)
101056	Granodiorite, metamorphic	2,661–2,706	2,689/18	0.38–0.55	0.45/0.08	0.00673–0.01563	0.00963/ 0.00409/ 0.00287	16,962–76,646	27,810/ 23,612/ 12,770	5
101057	Granite (to granodiorite), metamorphic, medium-grained	2,639–2,722	2,657/15	0.28–0.66	0.43/0.08	0.00007–0.02548	0.00442/ 0.01591/ 0.00346	3,352–54,100	14,727/ 11,237/ 6,374	64 (82 for elec. resis.)

Code (SKB)	Composition (and grain size) Name (IUGS/SGU)	Physical properties Density (kg/m^3)		Porosity (%)		Magnetic susceptibility (SI units)		Electrical resistivity in fresh water (ohm m)		N (No. of samples)
		Range	Mean/Std	Range	Mean/Std	Range	Geometric mean/ Std above mean/ Std below mean	Range	Geometric mean/Std above mean/Std below mean	
111057	Granite (to granodiorite), metamorphic, medium-grained, veined to migmatitic	No data available. Rock type affected by veining and migmatisation is similar to 101057								
101058	Granite, metamorphic, aplitic	2,620–2,646	2,635/9	0.36–0.48	0.40/0.05	0.00179–0.01722	0.00657/ 0.00691/ 0.00337	11,467–27,915	15,876/ 5,288/ 3,967	7
111051	Granitoid, metamorphic	No data available								
101051	Granodiorite, tonalite and granite, metamorphic, fine- to medium-grained	2,642–2,832	2,715/52	0.28–0.59	0.45/0.09	0.00014–0.02539	0.00096/ 0.00445/ 0.00079	5,862–18,252	9,932/ 4,220/ 2,962	16 (17 for mag. susc. and 22 for elec. resis.)
101061	Pegmatitic granite, pegmatite	2,621–2,637	2,627/6	0.45–0.64	0.55/0.07	0.00019–0.02028	0.00208/ 0.00746/ 0.00163	10,600–33,483	15,289/ 6,744/ 4,680	7 (9 for mag. susc. and 8 for elec. resis.)
111058	Granite, fine- to medium-grained	2,627–2,645	2,638/9	0.48–0.69	0.50/0.02	0.00010–0.00573	0.00085/0.00408 / 0.00070	6,974–13,017	8,849/ 2,770/ 2,115	3 (4 for mag. susc. and elec. resis.)

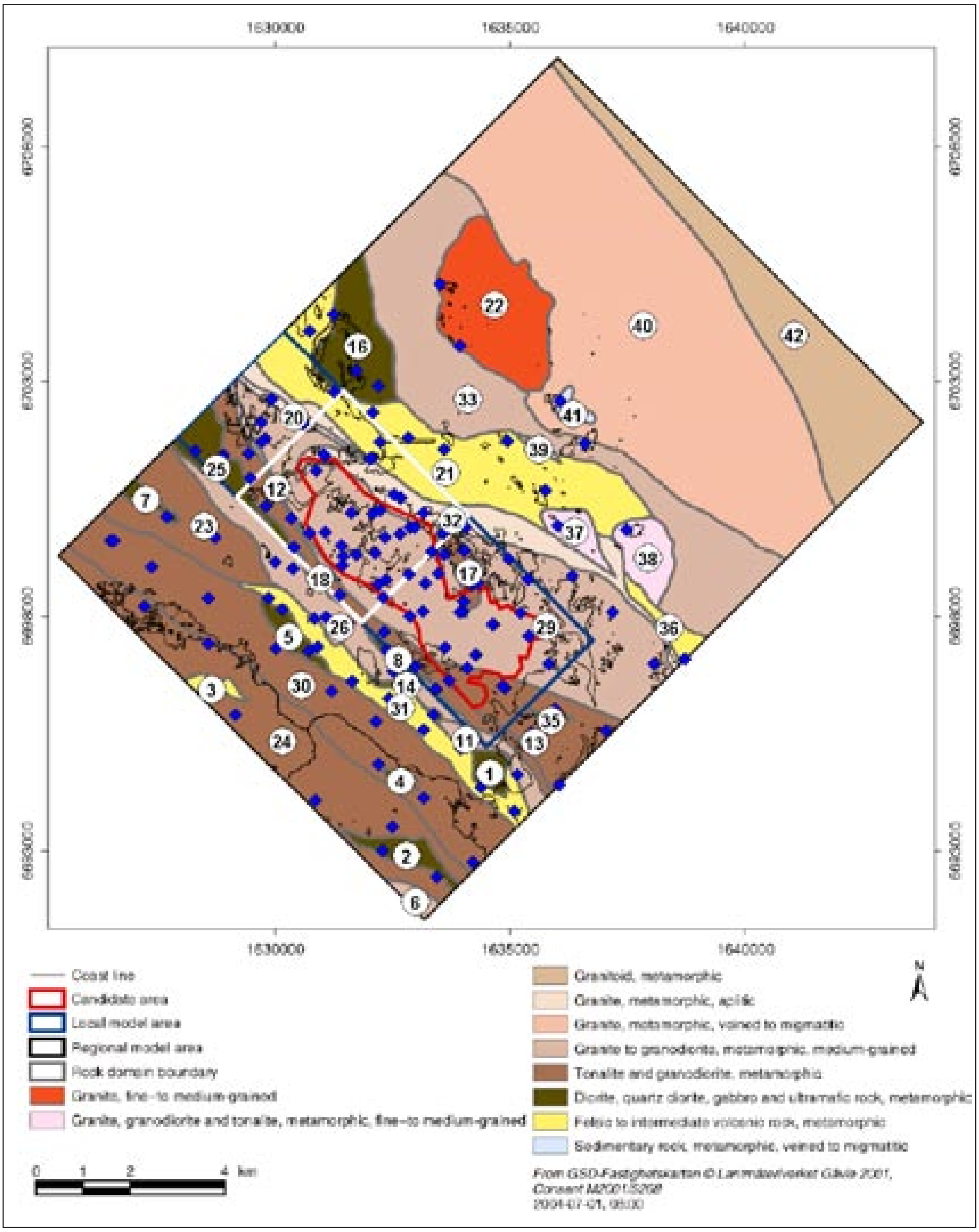


Figure 4-1. *Dominant rock type in the rock domain model, version 1.2. Digits represent the rock domain identity; RFM0xx. Petrophysical sample locations /3/ are marked with blue symbols. The local model area outlined in blue corresponds to that defined in model version 1.1 /2/. The local model area used in model stage 2.1 (and stage 2.2) /4, 5/ is outlined in white. Figure modified after /3/.*

4.2.2 Gravity data

Interpolation

The gravity data measured by the Geological Survey of Sweden (SGU) in the Forsmark area /7/ was delivered to SKB as a Bouguer anomaly. For the purposes of this activity, the data have been complemented with gravity data covering a regional area around Forsmark (Figure 4-2a). The Bouguer anomaly values in this area have been interpolated to a 200×200 m grid using the minimum curvature method (Surfer 8).

Regional – residual separation

The measured gravity field represents masses from the earth's surface down to considerable depths. Modelling the gravity responses in a local volume requires a proper representation of the regional field caused by mass sources outside the analysed rock volume. According to Jacobsen, 1985 /14/, upward continuation can be used as a standard separation filter for potential-field data and an upward continuation filter to twice the depth of the analysed rock volume will give an approximation to a regional field (Figure 4-2a). The three-dimensional rock domain model covers the regional model area and extends to a depth of 2.1 km. Hence, in this activity an upward continuation of the Bouguer anomaly to 4.2 km has been selected to represent the regional field in the area. This regional field is subtracted to obtain a first approximation of the residual gravity field that represents the rock domain volume under consideration (Figure 4-2b).

The regional gravity field above forms a saddle in the regional model area, defined by maxima to the northeast and southwest and minima to the northwest and southeast. This regional field has been manually smoothed to avoid an amplifying effect of a strong, marked, local maximum that occurs immediately northwest of the regional model area (Figures 4-2 and 4-3). This correction is only valid within a 20×20 km area extending over the regional model area; 1625000-1645000, 6690000-6710000 (Figure 4-3).

Finally, after modelling the initial model responses, a small regional variation remained that is specified by a sloping plane. The plane has a local origin at co-ordinate: 1634000,6700000, with a value 1.4 mgal and the slope is 0.14 mgal/km from NW to SE. This regional effect is limited to the regional model area and, after subtraction, the final residual anomaly field, used as the input to the gravity modelling, can be constructed (Figures 4-3a and 4-3b).

Boundary effect from the rock domain model

Since the rock domain model is spatially limited to the regional model area, a boundary effect will also occur. This means that calculated anomaly responses from the outer part of the model volume will be incorrect. Figure 4-4 shows the relative gravity anomaly from a slab with thickness D (the anomaly is independent of densities for the slab and for the background). In this work, the threshold has been set to 75% of the expected value which gives a boundary buffer with a width of ca 2 km. Thus, the evaluation of the gravity model is limited to a surface extension of 11×7 km. This is referred to as the boundary buffer and is centred inside the 15×11 km regional model area (Figure 4-3). The bedrock volume outside the rock domain model will have a background density that to some extent will compensate for the boundary effect and this is further discussed in section 4.3.

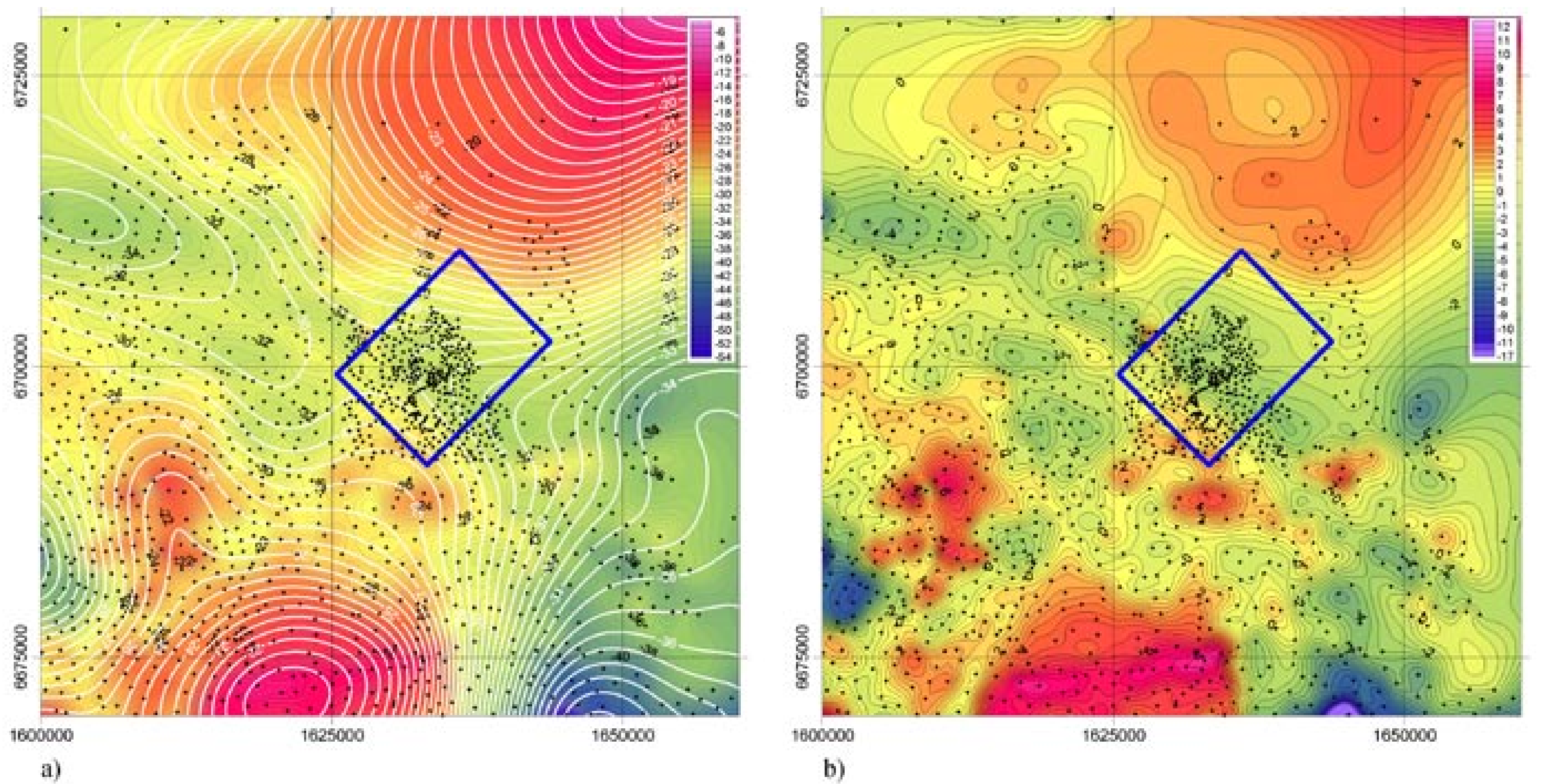


Figure 4-2. *a) Bouguer anomaly in colour [mgal] in a 60×60 km area surrounding the Forsmark regional model area (solid blue line), red colour is gravity high and blue is gravity low. Black dots represent survey stations. Overlay with white contours from the regional field defined by upward continuation to 4,200 m. b) The residual anomaly after subtracting the regional field from the Bouguer anomaly.*

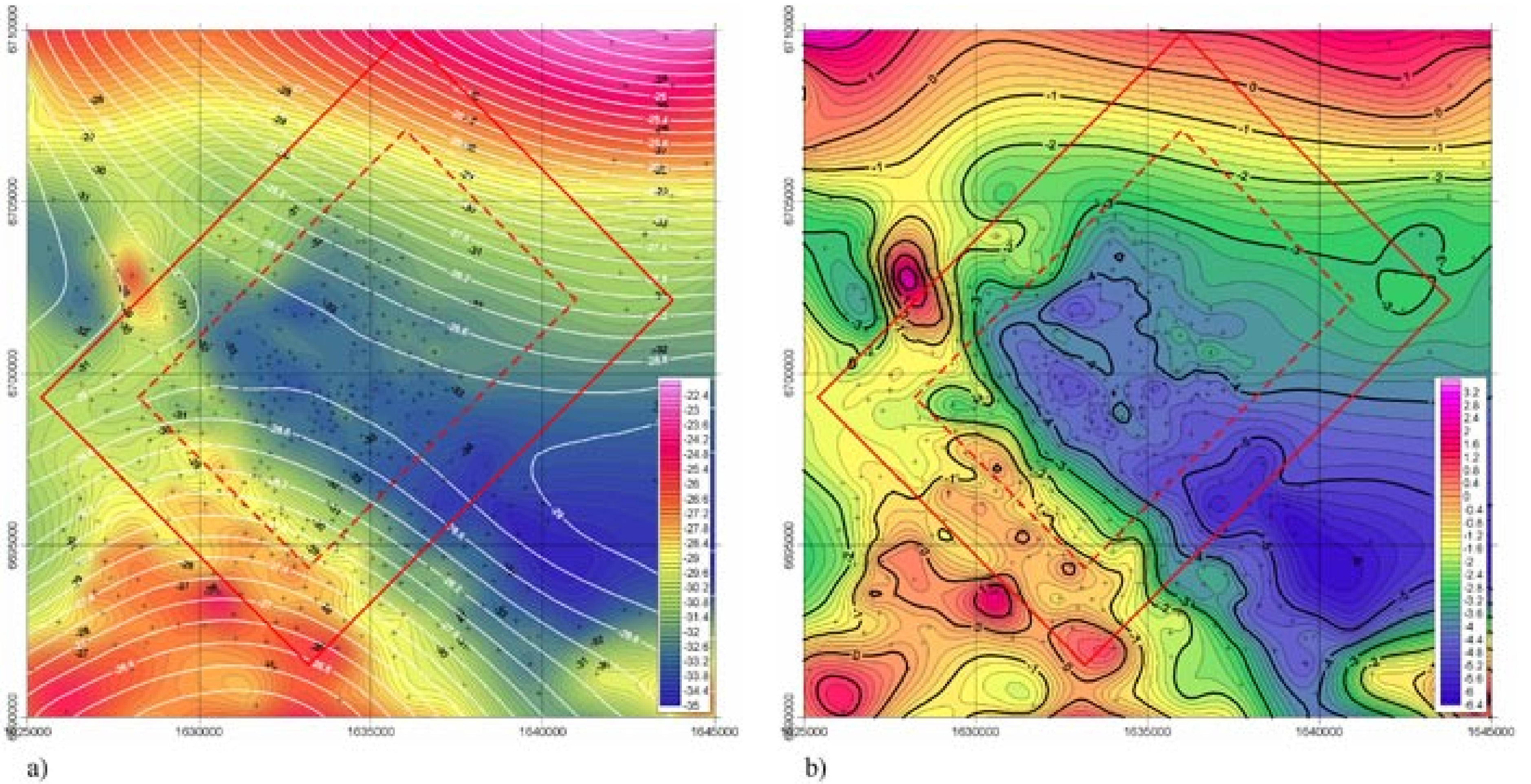


Figure 4-3. a) Bouguer anomaly in colour [mgal] in a 20×20 km area surrounding the Forsmark regional model area (solid red line), red colour is gravity high and blue is gravity low. Black symbols represent survey stations. Overlay with white contours from the final regional field. b) The final local residual anomaly [mgal] after subtracting the regional field from the Bouguer anomaly. This residual has been used as the input in the subsequent gravity modelling work. Observe that the best representation of the regional and residual field is within the boundary buffer area (dashed red line) within the regional model area.

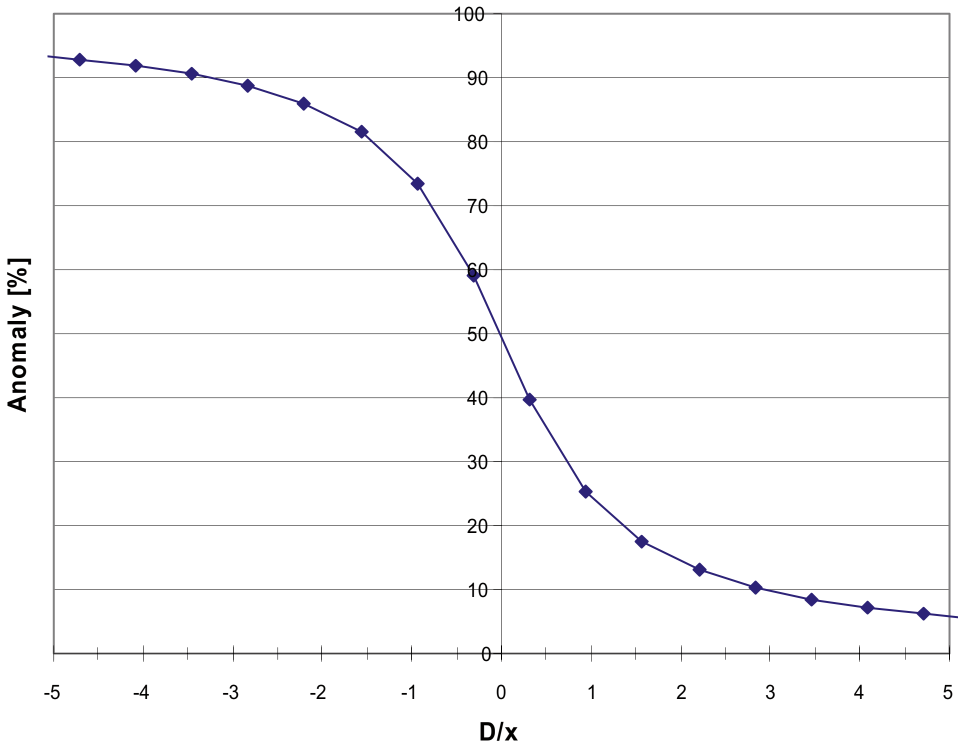


Figure 4-4. *Relative gravity anomaly response in %, for an infinite slab with thickness D at a distance D/x from the slab boundary. The slab boundary is located at D/x=0. D/x=1 shows the relative anomaly at a distance x equal to the slab thickness. The threshold for valid survey stations in this activity is set to D/x = –1, or 75% of the expected anomaly value, which means a distance of 2.1 km inward from the slab boundary and equal to the thickness for the regional model volume. The graph has been constructed by Hans Thunehed 2007, based on Parasnis 1979, (p. 75, 3.10d) /15/.*

4.2.3 Geological model

The rock domain model, RVS version 1.2 /3/ was delivered by SKB in dxf-format (Figure 4-5). According to available specifications, it was judged possible to transfer this format to the software Modelvision and to use it as a starting point for the gravity modelling. However, at an early stage, several technical difficulties arose concerning the interplay between the delivered SKB model and the modelling software used in this study. Fault-tracing these applications was both difficult and also time consuming. By good co-operation between the RVS support team at SKB, Encom Technology and GeoVista AB, the technical problems were identified and rectified, and the evaluation of the gravity data could be resumed. The major concerns were: specification of the rock domain volumes regarding facet orientation etc, body complexity, and geometric precision in input and output of body data.

A quality control of volumes and masses in the rock domain model was carried out, which involved a comparison of input and calculated mass, volume and density for each rock domain in the RVS model (Table 4-2). During stage 1, the rock domain mass was determined by simply multiplying the body density (Table 4-1) with body volumes calculated in Microstation. During stage 2, the mass was determined in Modelvision using a method for determination of total mass presented by Parasnis 1979, (p. 86, 3.22a) /15/. The anomaly field for each rock domain was calculated using a density based solely on the dominant rock type and this was carried out for a 200×200 m grid in a 60×60 km area, within which Figure 4-6 presents the central 20×20 km area around the regional model area. By summation of anomaly responses over the grid, a mass was determined for each rock domain. Modelvision also reports the volume of each body and, on the basis of these two values, a density can be calculated. A comparison between the input and the calculated densities shows small differences (Table 4-2).

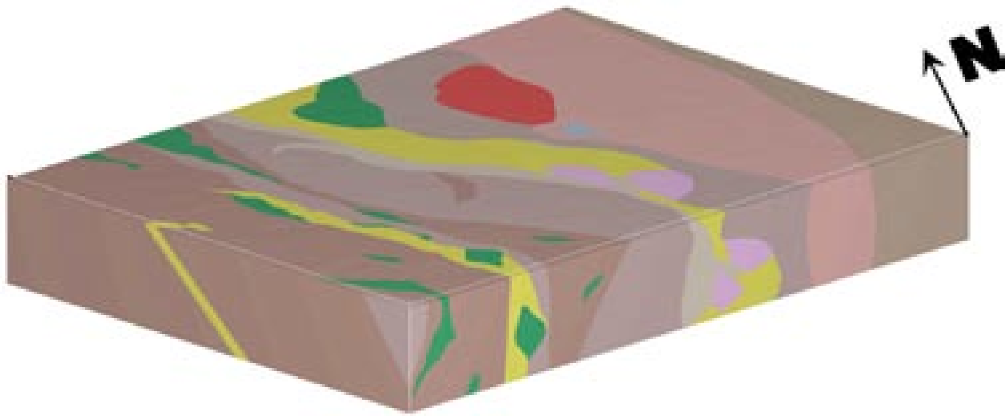


***Figure 4-5.** 3D-representation of the rock domain model version 1.2, see Figure 4-1 for rock domain identities and legend.*

Table 4-2. Quality control of Modelvision responses by comparing input and calculated mass for each individual rock domain.

Rock domain RFM...	Rock type SKB code	Density [kg/m³]	RVS Microstation Volume [m³]	Mass [Mton]	Modelvision Volume [m³]	Mass [Mton]	Density [kg/m³]	Density difference [kg/m³]
1	101004	3,045	693,192,000	2,111	693,192,000	2,105	3,037	–8
2	101033	2,934	742,655,000	2,179	742,655,000	2,174	2,928	–6
3	103076	2,732	699,442,000	1,911	699,442,000	1,911	2,732	0
4	101004	3,045	319,311,000	972	319,311,000	968	3,032	–13
5	101033	2,934	1,526,320,000	4,478	1,526,319,000	4,464	2,925	–9
6	101057	2,657	239,518,000	636	239,518,000	637	2,660	3
7	101033	2,934	923,704,000	2,710	923,704,000	2,702	2,926	–8
8	101033	2,934	447,298,000	1,312	447,298,000	1,309	2,927	–7
11	101057	2,657	681,740,000	1,811	681,740,000	1,813	2,659	2
12	101057	2,657	1,711,870,000	4,548	1,711,865,000	4,553	2,660	3
13	101054	2,737	4,250,370,000	11,633	4,250,368,000	11,633	2,737	0
14	101033	2,934	331,240,000	972	331,240,000	969	2,926	–8
16	101033	2,934	7,831,480,000	22,978	7,831,477,000	22,927	2,927	–7
17	101054	2,737	163,305,000	447	163,305,000	447	2,737	0
18	101054	2,737	5,991,480,000	16,399	5,991,477,000	16,397	2,737	0
20	101058	2,635	1,116,010,000	2,941	1,116,008,000	2,944	2,638	3
21	103076	2,732	35,233,500,000	96,258	35,233,464,000	96,255	2,732	0
22	111058	2,638	2,181,630,000	5,755	2,181,625,000	5,757	2,639	1
23	101054	2,737	12,383,300,000	33,893	12,383,253,000	33,889	2,737	0
24	101054	2,737	17,183,800,000	47,032	17,183,758,000	47,027	2,737	0
25	101033	2,934	4,970,580,000	14,584	4,970,577,000	14,545	2,926	–8
26	101057	2,657	9,761,710,000	25,937	9,761,713,000	25,964	2,660	3
29	101057	2,657	48,130,000,000	127,881	48,129,998,000	128,000	2,659	2
30	101054	2,737	28,844,400,000	78,947	28,844,366,000	78,939	2,737	0
31	103076	2,732	6,391,850,000	17,463	6,391,851,000	17,462	2,732	0
32	101058	2,635	11,148,800,000	29,377	11,148,831,000	29,410	2,638	3
33	101057	2,657	35,830,800,000	95,202	35,830,809,000	95,287	2,659	2
35	101033	2,934	103,536,000	304	103,536,000	304	2,932	–2
36	103076	2,732	289,111,000	790	289,111,000	790	2,732	0
37	101051	2,715	1,504,140,000	4,084	1,504,139,000	4,084	2,715	0
38	101051	2,715	1,458,890,000	3,961	1,458,888,000	3,961	2,715	0
39	101058	2,635	504,345,000	1,329	504,345,000	1,331	2,639	4
40	111057	2,657	78,609,200,000	208,865	78,609,152,000	209,056	2,659	2
41	106001	2,691	739,707,000	1,991	739,707,000	1,991	2,692	1
42	111051	2,715	22,829,900,000	61,983	22,829,937,000	61,996	2,716	1

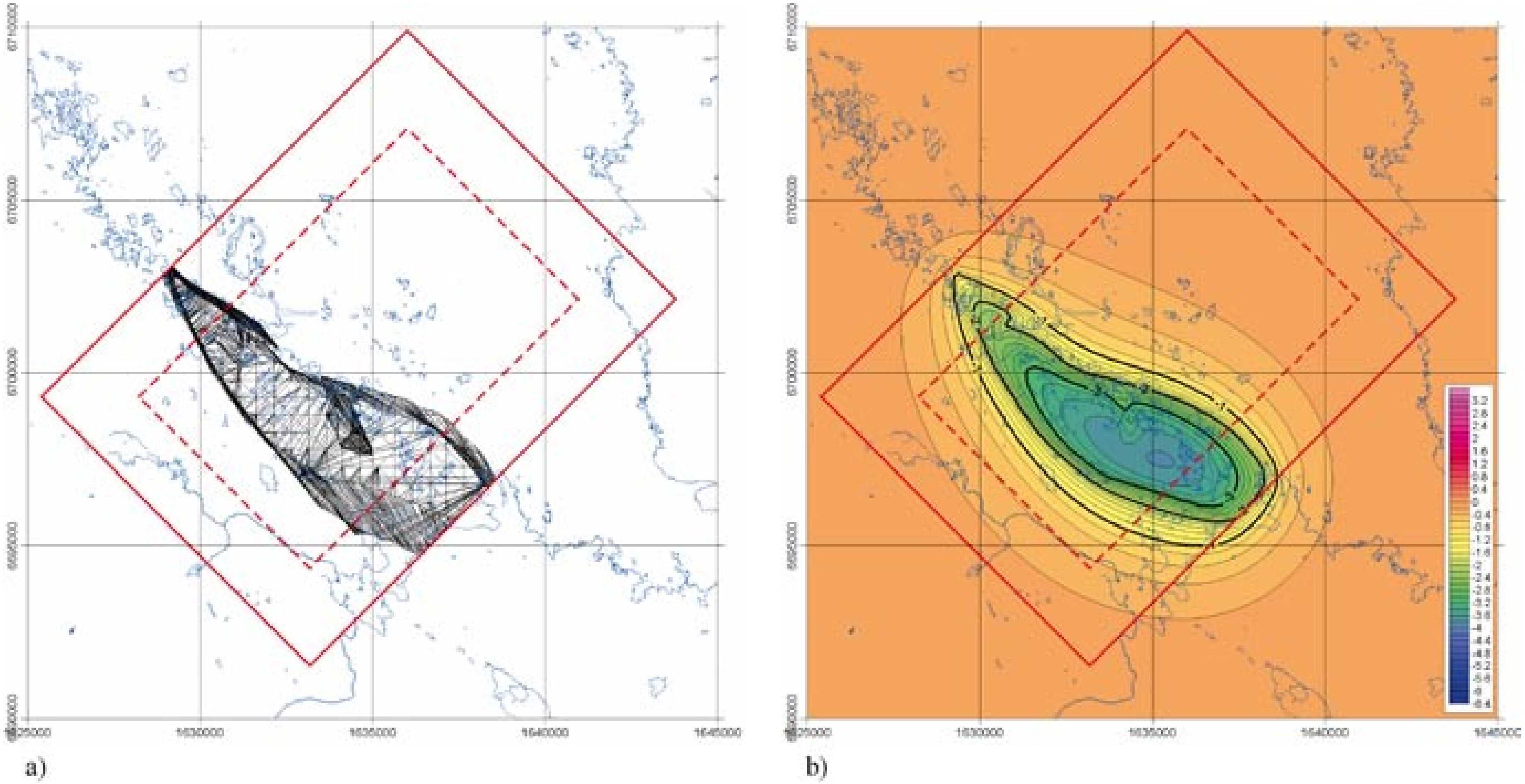


__Figure 4-6.__ a) Rock domain RFM029 with b) the gravity anomaly response [mgal] calculated with density 2,657 kg/m³ using Modelvision software. The density for RFM029 is lower than the background density 2,730 kg/m³ and, hence, a gravity minimum occurs (blue colours). The regional model area is shown as a solid red line and the boundary buffer area (showing valid responses) as a red dashed line.

4.3 Limitations and assumptions

It is apparent that this type of modelling work is restricted by the paucity of quantitative data that bear on the volumetric proportions of subordinate rock types. This problem has been addressed in the development of alternative models that do not solely take account of the density of the dominant rock type.

An important limitation is that there is no unique way of separating regional and residual anomalies /15/ based on gravity data alone. The regional-residual anomaly separation should be considered as a subjective method used to separate large-scale variations from local variations with shorter wave-length.

The surrounding density has been set to 2,730 kg/m³, bearing in mind the general bedrock composition in the area to the southwest of the Forsmark area. A change in this assumption will only change the base level of the modelling response but not the relative anomaly distribution within the model.

The buffer zone at the model boundary has been set to a slab function value at 75% of estimated correct anomaly value. Using the average density for the whole rock domain model (2,700 kg/m³) and the background density (2,730 kg/m³), an estimated error of ca 0.7 mgal at the buffer boundary, D/x=–1, can be calculated. However, at the centre of the model volume (D/x=–2.6) the error is reduced to 12% or ca 0.3 mgal. The gravity model response, according to these assumptions, is presented in Figure 4-7.

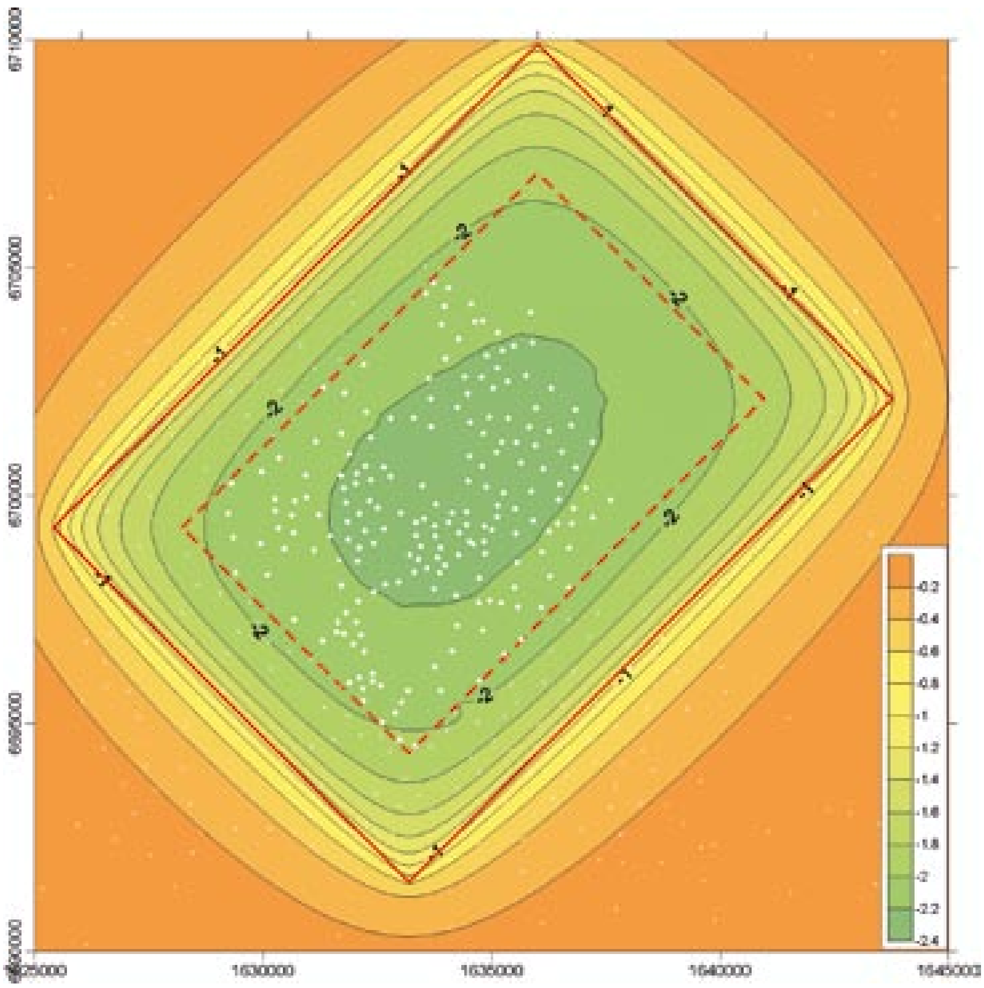


Figure 4-7. *Gravity model response [mgal] calculated from an average density of 2,700 kg/m³ for the whole rock domain model and a background density of 2,730 kg/m³. This figure illustrates the average anomaly effect caused at the rock domain model boundaries (solid red line). The relative error within the study area (dashed red line) is within 0.2–0.3 mgal.*

5 Results

5.1 Modelling of rock domains on the basis of gravity and petrophysical data

In the modelling of gravity responses, each rock domain in the geological model was assigned an initial density value based on the available petrophysical data and a first gravity response was calculated for the geological model. The density values at this stage in the modelling procedure correspond solely to the dominant rock type within each rock domain. The rock domain densities used are identical to those provided in model version 1.2, /3, Table 5-3/ and in Table 4-1 in this report. They are also summarised for each rock domain in Table 5-1 (column 3). The gravity response obtained at the first stage yields an initial model in the gravity modelling work.

Table 5-1. Petrophysical characteristics for the different stages in the gravity modelling. The single asterisk (*) indicates that the dominant rock type for the rock domain has been modified from version 1.2 to stage 2.1. The new code is shown in brackets. The double asterisk (**) marks the two rock domains in which volume proportion estimates for different rock types are available in the base model /3, 5/. For other rock domains in the base model, the numbers in brackets show the number of density determinations for the dominant rock type inside a rock domain that have been used to calculate a revised mean value. Where no data is available, the same density as in the initial model has been used. The triple asterisk (***) shows that the single densities in rock domain 37 and 38 have been calculated together.

Rock domain RFM...	Dominant Rock type SKB code	Initial model Density [kg/m^3]	Base model Density [kg/m^3]	Refined base model Density [kg/m^3]
1	101004	3,045	3,045 (1)	3,045
2	101033	2,934	2,882 (1)	2,845
3	103076	2,732	2,732 (0)	2,732
4	101004	3,045	3,045 (0)	3,045
5	101033	2,934	3,046 (2)	2,845
6	101057	2,657	2,657 (0)	2,657
7	101033	2,934	2,934 (0)	2,845
8	101033	2,934	2,879 (1)	2,845
11	101057	2,657	2,657 (0)	2,657
12	101057	2,657	2,688**	2,688
13*	101054 (101056)	2,737	2,685 (6)	2,681
14*	101033 (101004)	2,934	2,952 (1)	2,845
16	101033	2,934	2,858 (2)	2,845
17	101054	2,737	2,760 /16/	2,760
18*	101054 (101056)	2,737	2,746 (5)	2,700
20	101058	2,635	2,635 (1)	2,635
21	103076	2,732	2,692 (7)	2,681
22	111058	2,638	2,645 (1)	2,670
23	101054	2,737	2,796 (1)	2,696
24	101054	2,737	2,720 (2)	2,720
25	101033	2,934	2,913 (3)	2,845
26	101057	2,657	2,663 (5)	2,681
29	101057	2,657	2,675**	2,657
30	101054	2,737	2,718 (8)	2,718
31	103076	2,732	2,743 (8)	2,732
32	101058	2,635	2,638 (3)	2,657

Rock domain RFM...	Dominant Rock type SKB code	Initial model Density [kg/m³]	Base model Density [kg/m³]	Refined base model Density [kg/m³]
33	101057	2,657	2,654 (1)	2,654
35	101033	2,934	2,934 (0)	2,845
36	103076	2,732	2,681 (1)	2,681
37***	101051	2,715	2,739 (2)	2,685
38***	101051	2,715	2,739 (2)	2,685
39	101058	2,635	2,630 (1)	2,630
40	111057	2,657	2,657 (0)	2,700
41	106001	2,691	2,691 (1)	2,691
42	111051	2,715	2,715 (0)	2,715

At a second stage, the input density are more carefully adapted to the density values occurring within each rock domain by, firstly, compiling the actual density determinations for the rock types within the domain and, secondly, by taking account of subordinate rock types. Based on documented geological observations from surface and drill core, mixing between different rock types was also considered in rock domains RFM012 and RFM029. Quantitative estimates of the volumetric proportions of different rock types presented in both model version 1.2 /3/ and model stage 2.2 /5/ were tested. A base model that involves a more realistic gravity response was then calculated from the geological rock domain model.

In a final stage, the two model responses were compared with the measured gravity data and the input density values were selected, bearing in mind statistical deviations in the petrophysical data in combination with the mixing of dominant and subordinate rock types (see stage 2). By continuous iterations with adjustments of the rock domain densities and by comparing model and measured gravity responses, this provided a refined base model that has been used to assess validity and discrepancies in the rock domain model, version 1.2.

The calculated responses in each model are given both as the difference between the input local gravity anomaly and the model response calculated for each survey station (Figures 5-1a, 5-2a and 5-3a) as well as a model response in grid format (Figures 5-1b, 5-2b and 5-3b). The rock domains are marked by the rock domain identity number, RFM0xx.

Initial model

The rock domain density used in the initial model is the density of the dominant rock type in each domain, as presented in column 3 in Table 5-1 and /3/. The gravity modelling response is presented in Figures 5-1a and 5-1b and from this a generally poor fit is established with an overall mass surplus that indicates a general overestimation of the rock domain densities. In the north-eastern part of the study area, a mass deficiency is noted.

Base model

The rock domain density used in the base model is shown in Table 5-1, column 4. For some rock domains, this is based simply on the density of the dominant rock type in the domain and is identical to the initial model (Table 5-1, column 3 and /3/). However, for several rock domains, there are sufficient petrophysical data to adjust the density of the dominant rock type to the local conditions inside the domain. Furthermore, there are actually quantitative estimates of the volumetric proportions of each rock type inside rock domains RFM012 and RFM029 (candidate metagranite) based on the geological mapping of cored boreholes /3, 5/. The most important subordinate rock types occurring in these two rock domains are pegmatite and pegmatitic granite (101061), amphibolite (102017), fine- to medium-grained metagranitoid (101051) and also minor occurrences of younger granite (111058) and inclusions of supracrustal rocks (103076).

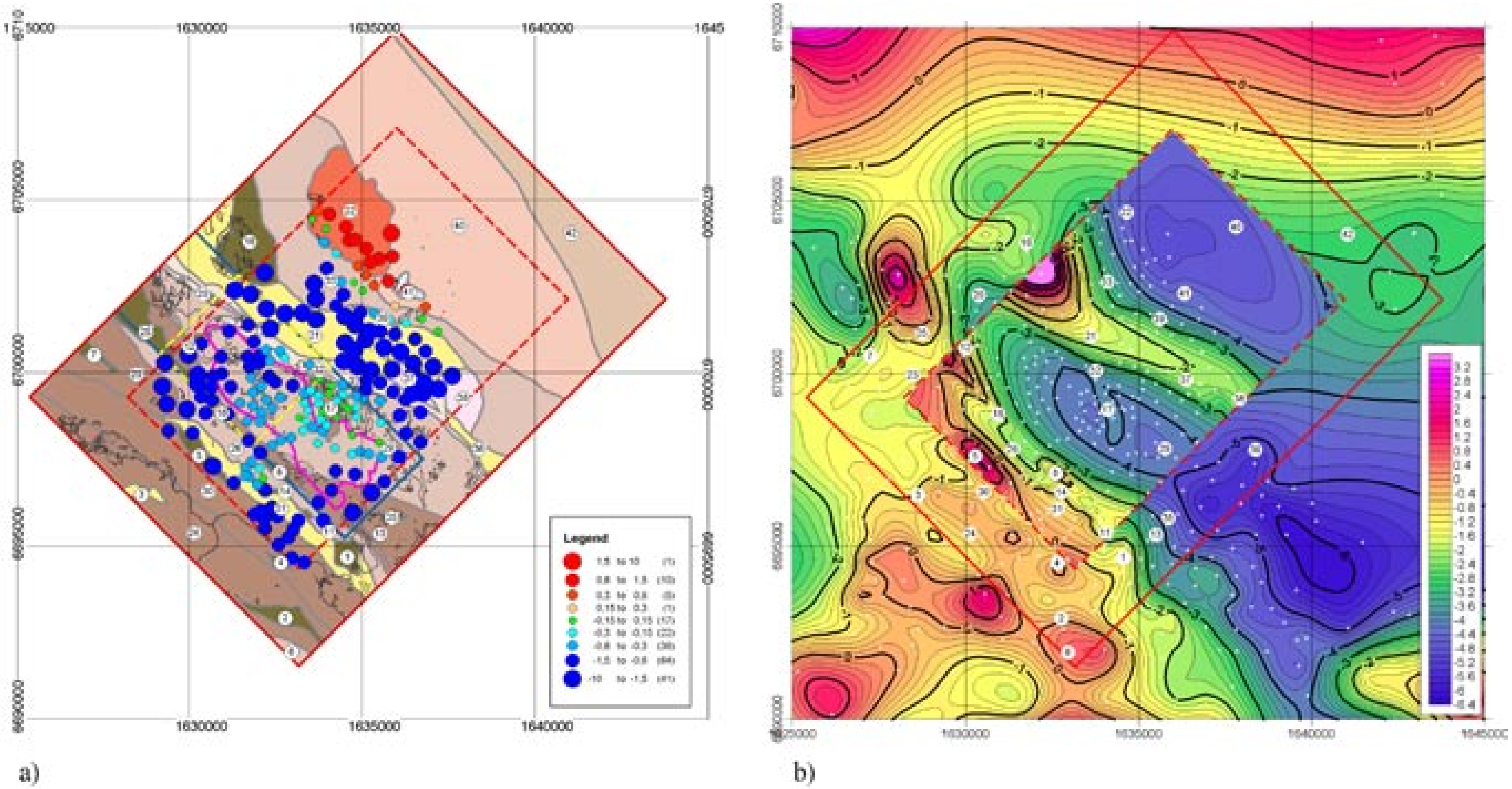


Figure 5-1. *Initial model for gravity response from rock domains, version 1.2, inside the regional model area (solid red line). Rock domains are numbered;* ⑧=RFM008, etc. *Responses are only shown within the boundary buffer area (dashed red line). a) Residual between the input gravity anomaly and the model anomaly [mgal], calculated for each survey station; blue dots indicate a mass surplus in the rock domain and red dots indicate a mass deficiency. The candidate area is shown with a solid magenta line. The local model area version 1.2 and stage 2.2 is shown with a solid blue line and a dashed yellow line, respectively. b) The model response [mgal] in grid format is provided as an inset map within the input, local gravity anomaly map; red is gravity high and blue is gravity low.*

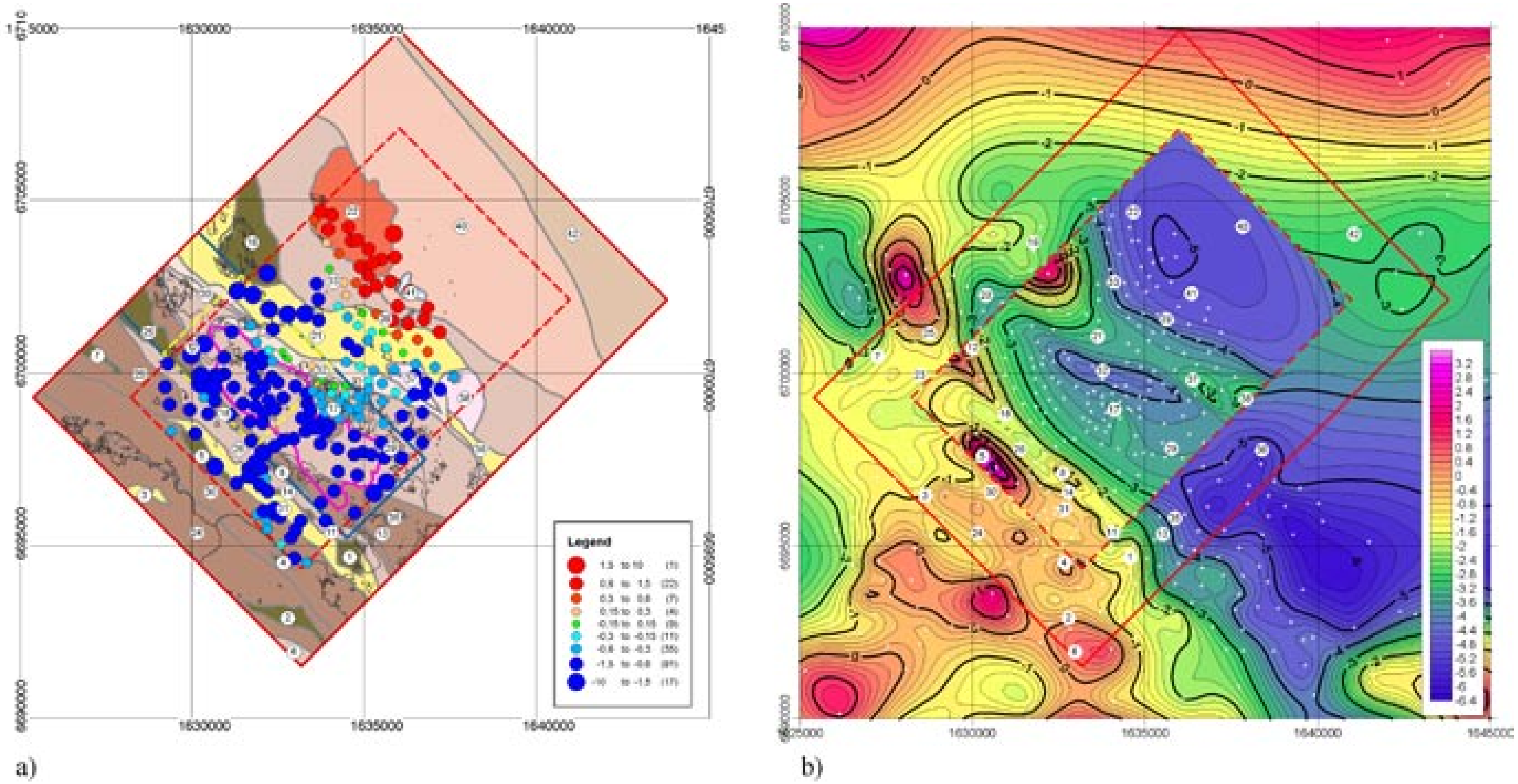


Figure 5-2. *Base model for the gravity response from rock domains, version 1.2, inside the regional model area (solid red line). Rock domains are numbered;* ⑧=RFM008, etc. *Responses are only shown within the boundary buffer area (dashed red line). a) Residual between the input gravity anomaly and the model anomaly [mgal], calculated for each survey station; blue dots indicate a mass surplus in the rock domain and red dots indicate a mass deficiency. The candidate area is shown with a solid magenta line. The local model area version 1.2 and version 2.2 is shown with a solid blue line and a dashed yellow line, respectively. b) The model response [mgal] in grid format is provided as an inset map within the input, local gravity anomaly map; red is gravity high and blue is gravity low.*

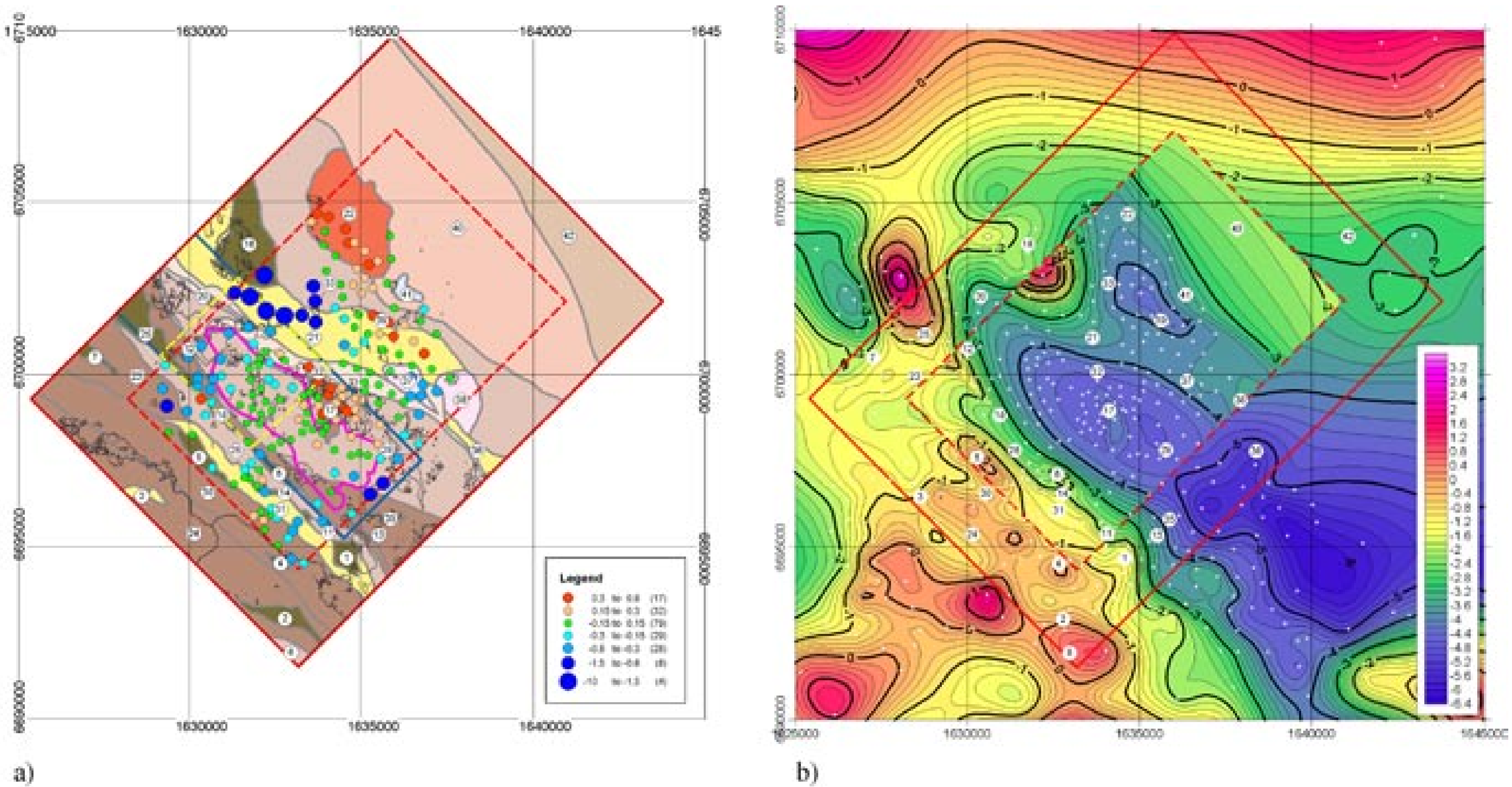
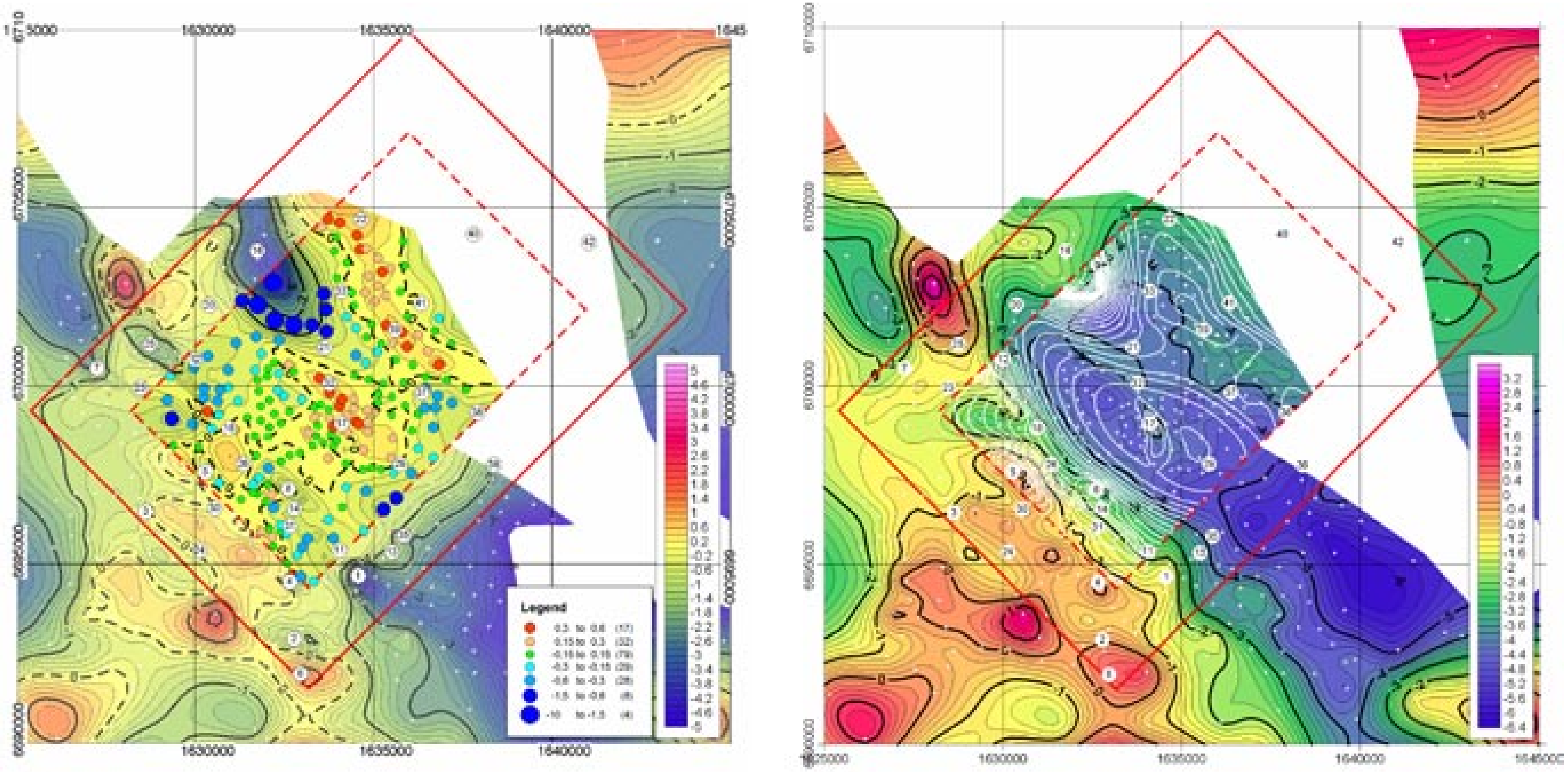


Figure 5-3. *Refined base model for modelling the gravity response from rock domains, version 1.2, inside the regional model area (solid red line). Rock domains are numbered;* ⑧=RFM008, etc. *Responses are only shown within the boundary buffer area (dashed red line). a) Residual between the input gravity anomaly and the model anomaly [mgal], calculated for each survey station; blue colours indicate a mass surplus in the rock domain model and red colours indicate a mass deficiency. The candidate area is shown with a solid magenta line. The local model area version 1.2 and version 2.2 is shown with a solid blue line and a dashed yellow line, respectively. b) The model response [mgal] in grid format is provided as an inset map within the input, local gravity anomaly map; red is gravity high and blue is gravity low.*



a) b)

Figur 5-4. *Refined base model for the gravity response from rock domains, model version 1.2, inside the regional model area (solid red line). Rock domains are numbered;* ⑧=RFM008, etc. *Responses shown are valid within the boundary buffer area (dashed red line). a) Residual between the input gravity anomaly and the model anomaly response [mgal], presented as a grid and as values in circles for each survey station; blue and red colours indicate rock domain mass surplus and mass deficiency, respectively. b) The model response [mgal] as white contours is inserted in the input, local gravity anomaly for comparison, red is gravity high and blue is gravity low.*

Table 5-2 presents alternative values for the proportion estimates for rock types in domains RFM012 and RFM029 /3, 5/ and alternative density calculations for each domain. For RFM029 and RFM012, the calculated weighted densities that take account of all available data /5/ are 2,675 ± 19 kg/m³ and 2,688 ± 27 kg/m³, respectively. The changes of density in other rock domains are based on local conditions identified in the petrophysical data /11, 12, 13/. By the use of GIS, the density data collected within each rock domain have been tagged with the rock domain identity and, when sufficient data are available, an average rock domain density for the domain has been calculated. For rock domain RFM017, the density of 2,760 kg/m³ reported in /16/ was used (Table 5-1).

The gravity modelling response in the base model is presented in Figures 5-2a and 5-2b. As in the initial model, there is a general mass surplus indicated in the south-eastern part of the study area and a mass deficiency in the north-eastern part. However, it is clear that more detailed quantitative data bearing on the proportions of different rock types in each domain are required, in order to provide a more realistic response. The subordinate rock types documented in detail in RFM029 and RFM012 are also present in many of the other rock domains and these conditions cannot be accounted for in the base model.

Table 5-2. Rock type distribution for rock domain RFM012 and RFM029 according to /3 and 5/.

Code (SKB)	Composition and grain size	Rock type density [kg/m³]	RFM029 (regional) ver 1.2	RFM029 (regional) stage 2.2	RFM029 (local) stage 2.2	RFM012 ver 1.2	RFM012 stage 2.2
101057	Granite (to granodiorite), metamorphic, medium-grained	2,657	84%	73%	74%	68%	59%
101061	Pegmatitic granite, pegmatite	2,627	2%	10%	13%	4%	12%
101051	Granodiorite to tonalite, metamorphic, fine- to medium-grained	2,715	10%	8%	5%	24%	16%
102017	Amphibolite	2,988	3%	5%	5%	2%	7%
111058	Granite, fine- to medium-grained	2,638	1%	2%	2%		1%
101058	Granite, metamorphic, aplitic. Altered (bleached) in RFM045	2,635		1%	1%		1%
103076	Felsic to intermediate volcanic rock, metamorphic	2,732				2%	3%
	Other rock types (background density)	2,730		1%	1%		1%
	Density		2,672	2,675	2,699	2,678	2,688
	Density, 1 sigma low		2,652	2,656	2,656	2,652	2,662
	Density, 1 sigma high		2,692	2,694	2,691	2,681	2,715

Refined base model

The rock domain density used initially in the refined base model is the same as that used in the base model. However, by recurrent adjustment of the rock domain density, following a comparison between model response and the local gravity anomaly, a refined gravity model has been developed. The selection of rock domain density has been limited to yield a good fit, but still holding a value that is consistent with the variance estimated for the dominant rock type (Tables 4-1 and 5-1). For some rock domains, there are also sufficient geological information to adjust the density to the local conditions inside the domain by taking account of subordinate rock types. The following refinements have been made:

The densities assigned to rock domains RFM013 and RFM018 have been changed from 2,737 kg/m³ in the initial model to 2,681 kg/m³ and 2,700 kg/m³, respectively, in the refined base model. This change corresponds to a compositional shift from tonalite to granodiorite. The modelling result provides support to the change of dominant rock type in RFM013 and RFM018 from 101054 (tonalite to granodiorite, metamorphic) in model version 1.2 to rock type 101056 (granodiorite, metamorphic) in model stage 2.1.

All rock domains with rock type code 101033 have been changed from a density corresponding to a gabbroic composition to a density corresponding to a dioritic composition, 2,845 kg/m³.

RFM021 has been given a density of 2,681 kg/m³, representative for a more rhyodacitic composition for the volcanic rock.

RFM022 has been given a density of 2,670 kg/m³ corresponding to a slightly denser granitic composition. However, this modification is still not sufficient to account for the mass increase in this area.

RFM026 has been given a density of 2,681 kg/m³, implying the occurrence of more mafic material (amphibolite?) inside the rock domain.

For RFM029, the mean of 54 local density determinations were tested for the dominant rock type in this domain. However, the calculated value of 2,652.3 kg/m³ used in the refined base model resulted in a clear mass deficiency. For this reason, the density was reset to 2,657 kg/m³, as in the initial model, implying the occurrence of more higher density rocks inside the rock domain. However, this density is somewhat lower than the calculated mean density that makes use of volumetric proportion data from boreholes (see Table 5-2).

RFM032 has been given a density of 2,657 kg/m³, which implies the occurrence of more mafic material (amphibolite?) in the aplitic metagranite 101058.

RFM037 and RFM038 have been given the lower granite density in the fine- to medium-grained Group C metagranitoid, 2,685 kg/m³. However, this is still not sufficient to account for the mass deficiency in the domains. It needs to be remembered that there are few data in these domains, which also lie close to the boundary of the buffer area.

RFM040 has little data and, hence, the density has been set to the average density for the model, 2,700 kg/m³.

The gravity modelling response in the refined base model is presented in Figures 5-3a and 5-3b. A generally good fit to the measured values is noted. The remaining discrepancies between model result and the local gravity anomaly are discussed further in section 5.2.

5.2 Discussion and conclusions

The main purpose with this activity has been to assess the validity of the geological rock domain model, version 1.2 /3/ and to identify discrepancies between the gravity models derived with the help of the rock domain model, version 1.2 /3/, and the local anomaly generated by the measured gravity data /7/. The model favoured here and used for comparison purposes is the so-called refined base model (see Figures 5-4a and 5-4b, and also Figures 5-3a and 5-3b).

An overall good correspondence between the refined base model and the gravity measurements is noted. In particular, in rock domain RFM029, there is generally a very good agreement between the refined base model that makes use of the rock domain model, version 1.2 and the measured gravity data. This correspondence supports an extension of rock domain RFM029 to a depth of 2.1 km, as suggested in the geological model. However, the domain density used in this model is slightly lower than the density based on the estimates of the volumetric proportion of rock types presented in model version 1.2 and model stage 2.2 /3, 5/.

The following, more significant discrepancies between the refined base model and the local anomaly generated by the gravity measurements are listed below:

RFM021 and RFM016

The most significant discrepancy occurs in the area extending from the SFR office to the SFR underground facility and further to the northwest. There is a prominent mass surplus in the rock domain model, version 1.2. This mass surplus is also supported by some additional survey stations located immediately northwest of the boundary buffer. It is speculated that this discrepancy is caused by a combination of an overestimation of the volume of gabbro (RFM016) that plunges towards the southeast in the rock domain model, and an underestimation of the volume of occurrence of pegmatite and pegmatitic granite that is known to be present and occurs as larger bodies around SFR (see Bedrock geological map, version 1.2 /6/ in /3/). The mass decrease due to the SFR tunnels and underground facilities is judged to be negligible.

RFM022

Although the density in the refined base model has been increased from initially 2,638 to 2,670 kg/m^3, a mass deficiency still remains. This may indicate that the volume of rock domain RFM022 is somewhat overestimated in the rock domain model. However, it needs to be kept in mind that there are few geological, gravity and petrophysical data in this part of the archipelago.

RFM017

The gravity model response in rock domain RFM017 shows a somewhat different extension of the gravity anomaly (Z-form) than the original data indicates. A small mass deficiency is also apparent, indicating that the rock domain is slightly underestimated in density and/or volume compared to domain RFM029.

RFM023

The south-eastern part of rock domain RFM023 shows a mass surplus. It is speculated that the occurrence of less dense, subordinate granitic rocks have not been sufficiently accounted for in the modelling work carried out here.

RFM037

A small mass surplus is apparent indicating that the rock domain is slightly overestimated in density and/or volume. The fine- to medium-grained Group C metagranitoid (101051) shows a large variation in composition and, therefore, selection of a correct density value is highly uncertain. In the refined base model, the density was set to a granitic composition inside the Group C range. However, a mass surplus remains. it needs to be kept in mind that there are again few geological, gravity and petrophysical data in this part of the archipelago.

The following, less significant discrepancies between the refined base model and the local anomaly generated by the gravity measurements are listed below:

RFM029

In the north-westernmost part of the candidate area, close to the nuclear power plant, a small mass surplus is indicated. This might be related to a slightly less dense granite that occurs north of the nuclear power plant (4 samples show a density of 2,650 kg/m^3) or to an underestimation of the volume proportion of pegmatite and pegmatitic granite (101061). RFM032 is rather narrow in this area and will probably not affect the results. It should be kept in mind that the metagranite north-west of rock domain RFM032 has been included in a separate rock domain (RFM034) in later geological models (stages 2.1 and 2.2 in /4, 5/).

RFM005

A small mass surplus is apparent indicating that the rock domain is slightly overestimated in density and/or volume.

RFM008 and RFM026

Discrepancy between the gravity models and the measured gravity data is simply caused by lack of gravity survey stations in these two domains.

It is apparent that the type of modelling carried out here is restricted by the paucity of quantitative data that bear on the volumetric proportions of subordinate rock types. This problem has been addressed to some extent by the development of alternative models that do not solely take account of the density of the dominant rock type.

Finally, the strong gravity anomaly (5–7 mgal) that is situated c 3 km northwest of the Forsmark nuclear power plant needs to be mentioned, even though it is located outside the study area (the boundary buffer area) and even outside the regional model area. A continuation and enlargement of the diorite-gabbro domain RFM025 towards the northwest, including also a higher density corresponding to rocks with more mafic or even ultramafic composition, may explain this gravity high. However, the shape and wavelength of the anomaly, and the fact that iron oxide mineralisation is known in the area, imply that an association to a metallic but non-magnetic ore can not be ruled out.

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Petrophysical rock domain data

Petrophysical data /5/ assigned to individual rock domains in model version 1.2 /3/. Data sorted on a rock domain basis according to the same model version.

Rock domain	Identity. PFM-number/ borehole	Rock unit order number	Rock type SKB code	Group	Regional or Local Model Area	East	North	Secup	Seclow	Remanence declination [°]	Remanence inclination [°]	Remanence intensity [A/m]	Volume susceptibility [SI]	Q-value [SI]	Wet density [kg/m³]	Porosity [%]	Electric resistivity [ohm]	Induced polarisation [mrad]	K [%]	U [ppm]	Th [ppm]	Natural exposure rate [microR/h]
1	PFM001201	1	101004	B1 serpentinized	RMA	1634445	6694496			100.5	77.6	9.18000	0.10853	1.70	2,786	0.88	228	353.7	0.0	0.1	0.0	0.1
1	PFM001205	1	101004	B1	RMA	1634487	6694774			30.7	61.2	4.67500	0.04572	2.26	3,045	1.04	52	724.8	0.0	0.0	0.0	0.0
2	PFM000522	1	101022	B2/B3	RMA	1632267	6693032			222.6	53.4	0.00146	0.00036	0.14	2,882	0.39	34227	4.8	0.1	0.0	0.0	0.2
5	PFM000243	2	101022	B2/B3	RMA	1630133	6698165			352.8	24.8	22.39000	0.01625	25.50	3,075	0.35	14228	11.4	0.4	0.1	0.0	0.7
5	PFM001515	1	101022	B2/B3	RMA	1630699	6697287			110.0	72.5	0.25570	0.05592	0.16	3,018	0.25	16583	26.3	0.4	1.1	0.1	1.4
5	PFM001515	2	101098	D2/D3	RMA	1630699	6697287												5.8	10.3	10.2	18.2
8	PFM000229	1	101033	B2/B3	RMA	1632363	6697308			6.9	67.6	0.00092	0.00053	0.05	2,879	0.37	13734	15.5	1.0	1.7	2.7	3.4
8	PFM000233	1	101038	B2/B3	RMA	1632971	6696951			348.6	73.9	0.04035	0.01079	0.15	2,738	0.27	29994	16.7	1.8	2.2	6.3	6.0
8	PFM000233	3	101061	D2/D3	RMA	1632971	6696951												4.4	8.3	15.4	16.6
12	KFM04A		101057	B8/B9	LMA	1631065	6699020	271.41	271.61			0.04577	0.00933	0.12	2,657	0.34	3949	3.4	3.2	4.7	19.3	13.7
12	KFM09A		103076	A1	LMA	1630521	6699890	460.32	460.47				0.00915		2,733							
12	KFM09A		102017	B4	LMA	1630536	6699908	422.49	422.64				0.00083		2,906							
12	KFM09A		102017	B4	LMA	1630509	6699876	489.44	489.59				0.00061		3,057							
12	KFM09A		101058	B10	LMA	1630528	6699898	443.11	443.27				0.00206		2,647							
13	PFM000692	1	101056	B7	RMA	1633697	6696651			140.8	73.4	0.14420	0.00673	0.37	2,704	0.50	76646	23.5	1.7	3.3	8.3	7.2
13	PFM001022	1	101053	B5/B6	RMA	1635946	6696045			27.3	62.4	0.00404	0.00066	0.14	2,687	0.32	16109	10.0	2.4	3.6	10.3	9.0
13	PFM001022	2	111059	D1	RMA	1635946	6696045												4.8	3.4	30.1	18.7
13	PFM001109	1	101054	B5/B6	RMA	1636040	6694416			66.3	–8.3	0.00040	0.00574	0.04	2,683	0.35	23206	14.0	1.5	5.2	14.4	9.9
13	PFM001616	1	101056	B7	RMA	1635448	6695552			217.5	79.9	0.08696	0.01101	0.21	2,661	0.55	17906	12.1	2.3	3.6	9.8	8.7
13	PFM001687	1	101056	B7	RMA	1637041	6695590			261.7	47.1	0.05840	0.01042	0.16	2,686	0.38	23122	11.3	2.5	5.1	8.7	9.6
13	PFM001869	1	101098	D2/D3	RMA	1634832	6696530			256.6	62.0	0.01789	0.00452	0.40	2,621	0.45	10865	8.4	4.4	4.8	26.6	18.0
13	PFM001870	1	101057	B8/B9	RMA	1634882	6696507			15.5	29.4	0.00075	0.00018	0.09	2,691	0.41	16220	10.4	2.3	4.6	9.4	9.2
14	PFM002087	1	101022	B2/B3	RMA	1633360	6695918			89.5	75.3	0.00033	0.00071	0.01	2,952	0.54	5412	15.9	0.8	0.7	1.3	2.1
16	PFM005206	1	101038	B2/B3	RMA	1632195	6702911			335.1	75.3	0.00112	0.00048	0.05	2,843	0.35	14283	10.3	1.7	2.8	6.7	6.4
16	PFM005215	1	101033	B2/B3	RMA	1631707	6703247			341.7	60.8	0.00020	0.00052	0.01	2,873	0.38	24139	12.3	1.3	2.1	4.6	4.8
17	PFM001162	1	101053	B5/B6	RMA	1634013	6698339			13.9	43.8	0.00131	0.00039	0.09	2,780	0.44	13124	7.0	2.0	2.8	7.5	7.1
17	PFM001162	2	101051	C	RMA	1634013	6698339			14.7	27.1	0.00047	0.00024	0.05	2,738	0.47	18252	9.7	1.8	1.9	10.1	7.1
17	PFM001162	3	101061	D2/D3	RMA	1634013	6698339												5.1	14.7	6.9	19.0
17	PFM001258	1	101098	D2/D3	RMA	1633997	6698126												5.0	4.5	28.0	19.0
17	PFM001258	2	101054	B5/B6	RMA	1633997	6698126												1.6	1.8	5.2	5.1
17	PFM001858	1	101053	B5/B6	RMA	1634302	6698716												2.2	4.9	10.3	9.6
17	PFM001858	2	101061	D2/D3	RMA	1634302	6698716												4.4	4.0	23.2	16.3

Rock domain	Identity. PFM-number/ borehole	Rock unit order number	Rock type SKB code	Group	Regional or Local Model Area	East	North	Secup	Seclow	Rema-nence declina-tion [°]	Rema-nence inclina-tion [°]	Rema-nence intensity [A/m]	Volume suscepti-bility [SI]	Q-value [SI]	Wet density [kg/m³]	Porosity [%]	Electric resistivity [ohm]	Induced polarisa-tion [mrad]	K [%]	U [ppm]	Th [ppm]	Natural exposure rate [microR/h]
17	PFM001859	1	101053	B5/B6	RMA	1634187	6698693			54.9	51.3	0.00033	0.00022	0.04	2,704	0.49	17508	7.9				
17	PFM001860	1	101053	B5/B6	RMA	1634136	6699145			31.4	69.5	0.00017	0.00020	0.02	2,703	0.53	13850	13.3	1.9	7.4	11.1	10.9
17	PFM001861	1	101053	B5/B6	RMA	1634000	6699427			265.3	35.6	0.00124	0.00030	0.14	2,722	0.47	19500	11.1	2.4	5.4	12.4	10.7
17	PFM001898	1	101053	B5/B6	LMA	1633567	6699793			68.7	52.2	0.00051	0.00032	0.03	2,743	0.45	13397	9.3	2.1	3.4	9.3	8.2
18	KFM04A		103076	A1	LMA	1631019	6698966	124.81	125.01			0.00154	0.00035	0.11	2,733	0.23	13367	7.7	1.7	3.7	9.4	7.8
18	KFM04A		101056	B7	LMA	1631017	6698963	116.91	117.08			0.00064	0.00034	0.05	2,641	0.38	5763	3.3	2.0	4.2	5.3	7.2
18	KFM04A		101057	B8/B9	LMA	1631038	6698988	186.83	187.03			0.00935	0.00166	0.14	2,653	0.40	5639	5.5	3.5	4.8	15.8	13.1
18	KFM09A		101057	B8/B9	LMA	1630467	6699833	582.95	583.10				0.01058		2,655							
18	KFM09A		101057	B8/B9	LMA	1630425	6699797	663.32	663.47				0.00003		2,643							
18	KFM09A		101057	B8/B9	LMA	1630393	6699773	719.37	719.52				0.00603		2,695							
18	PFM000293	1	101057	B8/B9. -K altered	LMA	1631372	6698480			132.9	80.1	0.10860	0.00510	0.33	2,722	0.50	25740	14.9	1.7	3.1	6.0	6.3
18	PFM000336	1	109014	A2	RMA	1633408	6696490			110.2	53.8	75.93000	0.12400	14.90	4,225	1.24	168	232.0	1.0	5.2	5.9	6.6
18	PFM000531	1	103076	A1	RMA	1633409	6696468												2.0	4.6	13.8	10.3
18	PFM000774	1	101053	B5/B6	RMA	1629415	6701476			169.7	72.7	0.21190	0.01087	0.36	2,758	0.31	14609	12.5	1.5	4.3	8.7	7.7
18	PFM000777	1	101053	B5/B6	LMA	1629786	6700365			310.3	80.4	0.15630	0.00425	0.71	2,794	0.38	19221	15.6	1.6	3.3	6.0	6.3
18	PFM001217	1	101053	B5/B6	RMA	1629455	6700952			187.5	56.3	0.29490	0.00472	0.66	2,831	0.33	10235	13.2	1.7	4.9	8.4	8.2
18	PFM001251	1	101058	B8/B9	LMA	1630330	6700093			339.7	80.5	0.00620	0.00340	0.09	2,679	0.44	45746	10.9	2.8	6.1	14.5	12.6
18	PFM002057	1	101056	B7	RMA	1632313	6697686			107.7	83.5	0.23760	0.01563	0.29	2,706	0.38	30905	16.0	1.0	4.4	8.3	6.9
20	PFM001636	1	101058	B10. -K altered	RMA	1629913	6702627			249.3	34.6	0.01772	0.00689	0.09	2,636	0.48	14403	12.6	2.0	5.2	18.5	12.1
21	PFM001051	1	101061	D2/D3	RMA	1631243	6702783												5.6	1.1	2.6	9.9
21	PFM001081	1	101058	B8/B9	RMA	1632822	6701811												3.9	3.7	22.3	15.0
21	PFM001156	1	103076	A1	LMA	1632016	6701371			7.0	41.8	0.00048	0.00006	0.16	2,686	0.53	9059	16.8	0.4	3.1	11.0	6.0
21	PFM001156	6	101058	B10	LMA	1632016	6701371												3.6	6.8	9.4	12.6
21	PFM001235	1	101033	B2/B3	LMA	1632065	6701402			19.3	66.1	0.00034	0.00092	0.01	3,023	0.46	10998	14.2	0.6	0.9	1.0	1.7
21	PFM001640	2	103086	A1	LMA	1632225	6701718			349.4	54.3	0.00017	0.00009	0.05	2,686	0.62	1725	10.1	2.9	6.8	14.3	13.0
21	PFM001654	1	103086	A1	RMA	1631228	6704448			104.3	83.3	2.17100	0.08472	0.53	2,768	0.34	5640	44.7	2.5	4.4	11.8	10.1
21	PFM001654	2	101061	D2/D3	RMA	1631228	6704448												5.5	4.4	9.4	13.9
21	PFM001729	1	103086	A1	RMA	1634929	6701743			102.6	67.6	0.00015	0.00007	0.06	2,650	0.44	7271	14.9	4.3	3.9	14.7	13.4
21	PFM001904	1	103086	A1	RMA	1632059	6702348			342.9	65.0	0.04525	0.02167	0.14	2,730	0.27	8215	12.1	1.4	4.1	9.0	7.4
21	PFM005204	1	101061	D2/D3	RMA	1633591	6701571												3.9	14.9	11.7	18.8
21	PFM005204	2	103086	A1	RMA	1633591	6701571			295.2	34.8	0.00191	0.00030	0.54	2,658	0.46	9087	16.7	2.9	5.7	15.0	12.6
21	PFM005223	1	101022	B2/B3	RMA	1630709	6704095			28.9	60.2	0.00075	0.00053	0.03	2,927	0.38	6824	13.1	0.5	0.2	0.7	1.0
21	PFM005252	1	103086	A1	RMA	1635746	6700698			318.2	53.9	0.04836	0.00569	0.15	2,669	0.36	9465	13.1	3.2	5.5	14.7	12.9
22	PFM001958	1	101098	D2/D3	RMA	1633914	6703795												3.7	8.7	4.5	12.4
22	PFM001958	2	101058	B8/B9	RMA	1633914	6703795			31.6	71.5	0.00180	0.00019	0.27	2,648	0.43	7212	8.0	2.4	7.6	11.3	11.9
22	PFM005245	1	111058	D1	RMA	1633496	6705094			347.5	82.7	0.00490	0.00042	0.29	2,645	0.51	7897	13.0	3.0	7.7	11.1	12.7
23	PFM000822	1	101057	C	RMA	1628705	6699696			117.2	68.1	0.04324	0.00171	0.42	2,655	0.46	8529	8.0	3.1	4.2	26.7	15.6
23	PFM000822	3	101061	D2/D3	RMA	1628705	6699696												3.1	17.2	51.6	31.5

Rock domain	Identity. PFM-number/ borehole	Rock unit order number	Rock type SKB code	Group	Regional or Local Model Area	East	North	Secup	Seclow	Rema-nence declina-tion [°]	Rema-nence inclina-tion [°]	Rema-nence intensity [A/m]	Volume suscepti-bility [SI]	Q-value [SI]	Wet density [kg/m³]	Porosity [%]	Electric resistivity [ohm]	Induced polarisa-tion [mrad]	K [%]	U [ppm]	Th [ppm]	Natural exposure rate [microR/h]
23	PFM002056	1	101053	B5/B6	RMA	1627695	6700134			2.1	48.2	0.00412	0.00074	0.11	2,796	0.51	15843	10.9	1.4	2.5	6.3	5.6
23	PFM002056	2	101098	D2/D3	RMA	1627695	6700134												3.5	17.7	33.6	26.7
24	PFM000513	1	101057	B8/B9	RMA	1630846	6694094			190.0	62.4	0.00030	0.00199	0.05	2,681	0.41	20119	8.3	3.1	4.6	13.1	11.6
24	PFM000513	2	101061	D2/D3	RMA	1630846	6694094												5.0	27.4	18.0	30.2
24	PFM000515	1	101057	B8/B9	RMA	1632489	6693531			117.5	48.4	0.02766	0.00191	0.14	2,679	0.48	25135	11.1	2.5	2.7	12.2	9.2
24	PFM000518	1	101022	B2/B3	RMA	1633431	6692462			346.0	81.8	0.65650	0.05543	0.33	3,120	0.36	29015	29.6	0.5	0.3	0.7	1.2
24	PFM000527	1	101053	B5/B6	RMA	1629134	6695922			161.1	69.2	0.10040	0.02043	0.10	2,697	0.39	22923	13.1	2.0	3.4	9.1	8.0
24	PFM000804	1	101053	B5/B6	RMA	1627207	6698235			30.2	75.2	0.00126	0.00029	0.09	2,743	0.42	6659	9.9	2.0	2.8	8.6	7.5
24	PFM001606	1	108011	A3	RMA	1628563	6697443			130.6	62.4	0.53280	0.04876	0.41	2,701	0.53	11875	20.0	5.1	4.1	12.8	14.3
25	PFM000253	1	101033	B2/B3	LMA	1630390	6699484			135.1	81.2	0.49560	0.01504	1.01	2,871	0.34	32410	21.1	1.0	1.5	3.3	3.5
25	PFM000780	1	101030	B2/B3	RMA	1628872	6701446			152.1	86.9	0.00114	0.00067	0.04	2,928	0.36	11123	15.4	0.9	1.4	2.1	2.8
25	PFM000850	1	101033	B2/B3	RMA	1628282	6701527			173.9	75.4	0.21860	0.03696	0.10	2,941	0.44	8016	33.9	0.8	1.2	1.6	2.5
26	PFM000245	1	101098	D2/D3	RMA	1630358	6699041			321.0	80.4	0.01963	0.00033	0.44	2,630	0.58	33483	11.8	4.2	17.5	25.7	25.2
26	PFM000259	1	101057	B8/B9	RMA	1629977	6699183			62.4	81.3	0.03619	0.01938	0.65	2,675	0.42	42221	18.2	2.3	3.8	10.6	9.1
26	PFM000259	2	101061	D2/D3	RMA	1629977	6699183												4.9	14.5	20.6	22.9
26	PFM000271	1	101058	B8/B9	RMA	1631554	6697873			15.7	71.9	0.02007	0.00982	0.13	2,657	0.40	14080	8.7	2.4	5.6	13.2	11.2
26	PFM000276	1	101058	B8/B9	RMA	1631059	6697997			318.6	78.3	0.00268	0.00017	0.35	2,664	0.39	25859	13.3	3.1	4.7	14.8	12.2
26	PFM001879	1	101057	B8/B9. -K altered	RMA	1632494	6696859			320.1	73.6	0.21170	0.02546	0.21	2,667	0.53	21764	16.9	2.2	3.9	10.1	8.9
26	PFM002221	1	101057	B8/B9	RMA	1635144	6694642			319.1	49.5	0.04780	0.00863	0.11	2,655	0.43	17233	11.5	2.8	5.5	13.0	11.7
29	KFM01A		102017	B4	LMA	1631365	6699554	355.10	355.30		44.5	0.00007	0.00067	0.00	2,989	0.24	36690	9.6	1.0	2.4	3.1	3.8
29	KFM01A		102017	B4	LMA	1631355	6699560	432.96	433.15										1.6	1.7	1.5	3.8
29	KFM01A		102017	B4	LMA	1631350	6699564	474.00	474.20		–49.6	0.00005	0.00069	0.00	3,048	0.32	18860	2.7	0.8	0.2	2.9	2.1
29	KFM01A		101057	B8/B9	LMA	1631389	6699537	110.06	110.26		69.3	0.09199	0.00946	0.24	2,663	0.28	33150	5.1	2.3	5.8	19.2	13.0
29	KFM01A		101057	B8/B9	LMA	1631369	6699551	317.80	318.00		58.8	0.08905	0.00896	0.24	2,660	0.29	19870	7.7	3.2	5.0	23.0	15.0
29	KFM01A		101057	B8/B9	LMA	1631350	6699564	476.60	476.80		68.8	0.01070	0.00026	1.01	2,678	0.34	9710	6.3	1.2	5.4	18.0	10.7
29	KFM01A		101057	B8/B9	LMA	1631313	6699588	706.00	706.20		73.8	0.08265	0.01647	0.12	2,661	0.29	10770	4.6	2.5	6.3	18.3	13.3
29	KFM01A		101057	B8/B9	LMA	1631268	6699620	947.80	948.00		54.4	0.21877	0.01262	0.42	2,661	0.36	3870	6.1	2.7	2.2	15.0	10.0
29	KFM01A		101051	C	LMA	1631377	6699545	241.90	242.10		79.1	0.00780	0.00039	0.49	2,713	0.40	8290	7.0	2.2	4.3	16.6	11.1
29	KFM01A		101051	C	LMA	1631343	6699568	521.40	521.60		77.7	0.02155	0.00033	1.60	2,688	0.28	6470	4.5	0.8	4.7	6.9	6.2
29	KFM01A		101051	C	LMA	1631263	6699624	969.90	970.10		–44.2	0.01401	0.00330	0.10	2,642	0.47	6050	2.4	4.0	6.0	42.4	22.8
29	KFM01D		102017	B4	LMA	1631455	6699613	151.51	151.61						2,886							
29	KFM01D		102017	B4	LMA	1631644	6699903	690.96	691.06						3,083							
29	KFM01D		101057	B8/B9	LMA	1631474	6699641	209.04	209.14						2,655							
29	KFM01D		101057	B8/B9	LMA	1631554	6699761	439.64	439.74						2,640							
29	KFM01D		101057	B8/B9	LMA	1631631	6699880	653.10	653.21						2,655							
29	KFM01D		101057	B8/B9	LMA	1631668	6699942	756.74	756.84						2,652							
29	KFM01D		101061	D2/D3	LMA	1631563	6699775	466.30	466.40						2,637							
29	KFM02A		101057	B8/B9	RMA	1633165	6698717	244.40	244.60		67.4	0.00130	0.00019	0.17	2,639	0.66	19570	7.0	4.2	2.2	22.4	14.5
29	KFM02A		101057	B8/B9	RMA	1633160	6698719	316.63	316.83		48.4	0.14230	0.01466	0.24	2,648	0.53	11860	9.0	3.5	3.6	16.7	12.7

Rock domain	Identity. PFM-number/ borehole	Rock unit order number	Rock type SKB code	Group	Regional or Local Model Area	East	North	Secup	Seclow	Rema-nence declina-tion [°]	Rema-nence inclina-tion [°]	Rema-nence intensity [A/m]	Volume suscepti-bility [SI]	Q-value [SI]	Wet density [kg/m³]	Porosity [%]	Electric resistivity [ohm]	Induced polarisa-tion [mrad]	K [%]	U [ppm]	Th [ppm]	Natural exposure rate [microR/h]
29	KFM02A		101057	B8/B9	RMA	1633160	6698719	317.45	317.65		9.4	0.06524	0.01260	0.13	2,650	0.46	10240	11.7	3.0	5.0	13.2	11.7
29	KFM02A		101057	B8/B9	RMA	1633157	6698721	350.60	350.80		63.4	0.06548	0.01057	0.15	2,654	0.44	16600	5.9	3.0	4.0	17.2	12.3
29	KFM02A		101057	B8/B9	RMA	1633157	6698721	351.00	351.20		55.6	0.06076	0.01067	0.14	2,659	0.31	16580	3.8	3.5	6.8	15.4	14.3
29	KFM02A		101057	B8/B9	RMA	1633125	6698742	712.25	712.45		58.0	0.00195	0.00040	0.12	2,649	0.37	10250	4.6	3.5	7.6	16.4	15.1
29	KFM02A		101057	B8/B9	RMA	1633099	6698763	949.67	949.87		46.6	0.49025	0.02157	0.55	2,655	0.35	4370	4.8	1.0	19.0	19.0	19.3
29	KFM02A		101057	B8/B9	RMA	1633098	6698763	953.48	953.68		55.0	0.46113	0.01948	0.58	2,652	0.36	4330	5.5	3.0	4.6	15.2	12.0
29	KFM02A		101051	C	RMA	1633141	6698730	552.43	552.63		89.0	0.00477	0.00100	0.12	2,648	0.38	11360	3.5	3.6	8.2	29.4	19.6
29	KFM02A		101051	C	RMA	1633103	6698759	915.90	916.10		76.0	0.00454	0.00046	0.24	2,832	0.33	11060	8.5	1.2	2.0	9.5	6.0
29	KFM02A		101057	B8/B9. Episyenite	RMA	1633164	6698718	263.15	263.35		53.8	0.00450	0.00019	0.57	2,568	1.97	3610	5.4	3.4	3.7	22.1	14.3
29	KFM02A		101057	B8/B9. Episyenite	RMA	1633163	6698718	277.90	278.10		–33.2	0.01095	0.00022	1.24	2,263	8.47	1280	7.9	4.5	5.0	18.7	15.6
29	KFM02A		101057	B8/B9. Episyenite	RMA	1633161	6698719	295.45	295.64		9.9	0.02626	0.00031	2.06	2,064	13.06	1060	6.5	4.6	5.9	23.2	17.8
29	KFM03A		101054	B5/B6	RMA	1634614	6697847	239.44	239.64			0.00087	0.00037	0.06	2,786	0.45	9494	5.2	1.4	1.2	11.2	6.3
29	KFM03A		101057	B8/B9	RMA	1634620	6697848	165.50	165.70		10.1	0.04101	0.00908	0.11	2,656	0.38	13820	4.1	3.5	2.1	13.7	10.8
29	KFM03A		101057	B8/B9	RMA	1634598	6697846	432.75	432.95		22.1	0.43080	0.01295	0.81	2,654	0.43	10460	3.5	2.7	6.5	11.0	11.5
29	KFM03A		101057	B8/B9	RMA	1634591	6697848	504.00	504.20		20.2	0.07020	0.00878	0.20	2,655	0.45	7590	3.2	3.3	3.3	20.3	13.3
29	KFM03A		101057	B8/B9	RMA	1634580	6697851	619.80	620.00		34.5	0.00961	0.00017	1.41	2,651	0.58	8130	4.5	2.8	4.3	19.9	13.0
29	KFM03A		101057	B8/B9	RMA	1634557	6697861	856.82	857.02		34.5	0.06058	0.01337	0.11	2,654	0.51	7540	2.8	3.5	0.8	13.7	10.0
29	KFM03A		101057	B8/B9	RMA	1634546	6697867	957.20	957.40		54.8	0.04029	0.00952	0.10	2,650	0.50	34320	7.5	3.4	7.4	22.6	16.8
29	KFM03A		101051	C	RMA	1634609	6697845	310.49	310.75		25.7	0.00232	0.00045	0.13	2,810	0.33	8260	3.9	1.4	2.4	7.1	5.7
29	KFM03A		111058	D1	RMA	1634620	6697849	157.00	157.20		8.4	0.00733	0.00573	0.03	2,627	0.69	7920	5.2	4.2	8.2	22.1	18.2
29	KFM03B		101061	D2/D3	RMA	1634614	6697844	60.46	60.60		23.5	0.00046	0.00019	0.06	2,637	0.59	11790	13.0	4.9	12.1	37.7	26.5
29	KFM04A		102017	B4	LMA	1631237	6699233	737.55	737.75			0.00052	0.00051	0.03	2,907	0.47	742	33.9	1.2	2.4	7.0	5.5
29	KFM05A		102017	B4	LMA	1631893	6699365	356.52	356.72		6.8	0.00059	0.00064	0.02	2,888	0.25	7234	2.4	0.8	1.0	1.9	2.4
29	KFM05A		101057	B8/B9	LMA	1631786	6699355	152.28	152.48		57.2	0.04874	0.01095	0.11	2,655	0.30	9898	2.9	2.9	4.5	20.0	13.4
29	KFM05A		101057	B8/B9	LMA	1631848	6699362	272.52	272.72		54.9	0.08380	0.00829	0.25	2,647	0.37	14337	3.2	3.4	2.2	18.6	12.2
29	KFM05A		101057	B8/B9	LMA	1631862	6699363	298.62	298.82		50.7	0.00794	0.00382	0.05	2,655	0.33	9280	2.6	3.1	2.8	17.0	11.6
29	KFM05A		101051	C	LMA	1632083	6699357	691.34	691.54		74.0	0.05214	0.00170	0.75	2,712	0.26	11222	6.1	1.6	2.0	7.6	6.0
29	KFM06A		101058	B10	LMA	1632173	6699933	637.33	637.54		44.1	0.01263	0.00274	0.11	2,649	0.35	18424	7.4	3.9	2.9	15.5	12.4
29	KFM06A		101057	B8/B9. -K altered	LMA	1632128	6699985	756.91	757.11		21.3	0.45120	0.00088	12.48	2,657	0.41	18971	10.0	0.5	7.1	18.6	10.9
29	KFM06A		101058	B10. -K altered	LMA	1632106	6700014	817.83	818.03		–48.3	0.00280	0.00030	0.23	2,656	0.27	22247	9.3	0.4	7.3	14.7	9.7
29	KFM06A		101058	B10. -K altered	LMA	1632095	6700030	851.08	851.28		52.0	0.01190	0.00769	0.04	2,649	0.28	16226	4.0	0.3	9.0	20.1	12.2
29	KFM06A		101058	B10. -K altered	LMA	1632066	6700076	938.95	939.15		31.9	0.00599	0.00321	0.05	2,644	0.34	17022	5.5	0.6	2.4	24.8	10.1
29	KFM09A		102017	B4	LMA	1630623	6700056	121.80	121.95				0.00086		2,941							
29	KFM09A		101051	C	LMA	1630611	6700030	174.08	174.23				0.00548		2,644							
29	KFM09A		101057	B8/B9	LMA	1630569	6699954	328.24	328.39				0.00010		2,669							

Rock domain	Identity. PFM-number/ borehole	Rock unit order number	Rock type SKB code	Group	Regional or Local Model Area	East	North	Secup	Seclow	Rema-nence declina-tion [°]	Rema-nence inclina-tion [°]	Rema-nence intensity [A/m]	Volume suscepti-bility [SI]	Q-value [SI]	Wet density [kg/m³]	Porosity [%]	Electric resistivity [ohm]	Induced polarisa-tion [mrad]	K [%]	U [ppm]	Th [ppm]	Natural exposure rate [microR/h]
29	PFM000168	1	101058	B8/B9	LMA	1632323	6699705			16.8	32.2	0.06112	0.00922	0.17	2,656	0.41	22234	8.4	3.1	4.5	14.9	12.1
29	PFM000168	2	101058	C	LMA	1632323	6699705												2.2	6.5	22.5	14.3
29	PFM000168	3	101061	D2/D3	LMA	1632323	6699705												3.9	3.8	17.0	13.5
29	PFM000173	1	101058	B8/B9	LMA	1633329	6699400			88.0	49.7	0.05017	0.01062	0.16	2,648	0.36	16797	8.1	3.1	5.1	15.0	12.5
29	PFM000196	1	101058	C	LMA	1631437	6699289			89.2	82.9	0.00017	0.00015	0.03	2,683	0.59	12025	12.7	2.6	3.4	24.3	13.5
29	PFM000197	1	101058	B8/B9	RMA	1634276	6697201			189.0	61.7	0.02849	0.00515	0.24	2,646	0.49	16694	9.3	3.8	4.8	19.7	14.8
29	PFM000198	2	101098	D2/D3	RMA	1634253	6697205			189.9	68.9	0.01303	0.00349	0.49	2,622	0.51	14814	9.3	4.4	3.8	24.1	16.4
29	PFM000203	1	101058	B8/B9	RMA	1633609	6697357			122.2	73.1	0.09836	0.01974	0.22	2,655	0.42	19566	6.6	2.8	5.1	16.9	12.6
29	PFM000206	1	101058	B8/B9	RMA	1633474	6698933			289.4	71.8	0.01278	0.00363	0.07	2,652	0.52	21287	8.8	3.2	2.5	16.4	11.6
29	PFM000214	1	101058	B8/B9	RMA	1633594	6699329			98.4	69.1	0.07959	0.01021	0.18	2,654	0.58	10312	12.5	3.1	4.1	16.7	12.4
29	PFM000216	1	101058	B8/B9	LMA	1632840	6698919			56.9	47.6	0.03779	0.00675	0.14	2,648	0.44	16115	4.1	3.4	4.4	15.7	12.8
29	PFM000658	1	101057	B8/B9	LMA	1631413	6699102			129.7	84.9	0.03607	0.00626	0.13	2,642	0.42	22026	7.4	3.5	6.4	15.9	14.2
29	PFM000666	1	101058	B8/B9	RMA	1633921	6698103												3.2	3.2	21.0	13.4
29	PFM000680	1	101098	D2/D3	RMA	1634617	6697848			87.7	71.4	0.25420	0.00498	0.33	2,627	0.64	14129	6.8	4.7	2.9	22.2	15.7
29	PFM000680	2	101058	B8/B9	RMA	1634617	6697848			163.1	59.6	0.01452	0.00420	0.09	2,649	0.53	21964	8.4	3.6	2.5	16.9	12.2
29	PFM000680	5	101061	D2/D3	RMA	1634617	6697848						0.00057						5.3	7.0	17.2	17.6
29	PFM000683	1	101058	B8/B9. -K altered	RMA	1635393	6697604			149.4	50.4	0.04505	0.00721	0.11	2,648	0.46	27415	5.8	2.0	6.6	13.6	11.3
29	PFM000685	1	101058	B8/B9	RMA	1635210	6698095			157.5	45.3	0.07583	0.01277	0.16	2,655	0.48	20049	9.1	3.2	3.5	16.4	12.1
29	PFM000685	3	101061	D2/D3	RMA	1635210	6698095												4.7	2.3	20.4	14.9
29	PFM000685	4	111058	D1	RMA	1635210	6698095												4.2	6.3	29.9	19.5
29	PFM000687	1	101058	B10	RMA	1634082	6696919			97.3	53.6	0.01583	0.00584	0.09	2,620	0.36	27915	10.5	4.1	6.4	27.9	18.9
29	PFM000694	1	101056	B8/B9	LMA	1632287	6698425			298.5	73.8	0.03760	0.00506	0.17	2,655	0.50	20526	6.0	3.3	3.8	14.1	11.7
29	PFM000695	1	101058	B8/B9	LMA	1632180	6698702			113.3	34.8	0.11580	0.02148	0.11	2,646	0.45	25212	7.0	3.5	6.1	19.3	15.0
29	PFM000698	1	101058	B8/B9	LMA	1631052	6699798			157.4	73.3	0.09841	0.00790	0.17	2,651	0.43	22813	8.7	2.3	4.7	15.9	11.3
29	PFM000698	5	101051	C	LMA	1631052	6699798						0.00014									
29	PFM000701	1	101058	B8/B9	LMA	1631601	6700223			118.5	65.6	0.05690	0.00771	0.13	2,644	0.42	13785	7.6	2.9	4.0	17.5	12.2
29	PFM000703	2	101051	C	LMA	1632226	6700277			30.6	55.3	0.02214	0.00348	0.09	2,712	0.53	10461	11.1	1.9	3.0	10.4	8.0
29	PFM000706	2	101058	B10	LMA	1632056	6700202			90.4	64.4	0.06223	0.01722	0.10	2,646	0.45	13447	10.5	2.8	4.9	15.5	12.1
29	PFM000722	1	101058	B8/B9. -K altered	LMA	1630850	6701111			343.2	61.8	0.00074	0.00017	0.10	2,654	0.37	20518	6.9	1.5	6.7	16.7	11.7
29	PFM000722	3	111059	D1	LMA	1630850	6701111						0.00010									
29	PFM000726	1	101098	D2/D3	LMA	1630715	6699787			356.3	68.8	0.11670	0.02028	0.20	2,631	0.48	17936	4.6	2.9	16.0	14.7	18.9
29	PFM000726	3	101061	D2/D3	LMA	1630715	6699787												3.0	61.7	36.4	54.3
29	PFM000770	1	101058	B8/B9	RMA	1629704	6701719			156.3	84.4	0.08799	0.00817	0.25	2,649	0.41	20787	9.4				
29	PFM000772	1	101058	B8/B9	RMA	1629778	6701787												3.5	5.7	16.4	13.8
29	PFM000890	1	101058	B8/B9	RMA	1633190	6698713			44.4	78.0	0.03289	0.00425	0.21	2,649	0.52	13055	8.1	3.4	2.2	13.4	10.7
29	PFM001043	1	101058	B8/B9	RMA	1630585	6702115			154.9	69.0	0.11290	0.01431	0.16	2,647	0.30	20478	11.1	3.0	7.1	16.1	13.9
29	PFM001159	1	101058	B8/B9	LMA	1632635	6699761			26.8	77.9	0.04882	0.00465	0.24	2,656	0.40	20022	13.2	3.4	4.5	13.5	12.0
29	PFM001169	2	102017	B4	LMA	1632851	6699917			16.2	52.9	0.00012	0.00071	0.00	2,928	0.30	11211	15.3	1.3	1.1	2.6	3.4

Rock domain	Identity. PFM-number/ borehole	Rock unit order number	Rock type SKB code	Group	Regional or Local Model Area	East	North	Secup	Seclow	Rema-nence declina-tion [°]	Rema-nence inclina-tion [°]	Rema-nence intensity [A/m]	Volume suscepti-bility [SI]	Q-value [SI]	Wet density [kg/m³]	Porosity [%]	Electric resistivity [ohm]	Induced polarisa-tion [mrad]	K [%]	U [ppm]	Th [ppm]	Natural exposure rate [microR/h]
29	PFM001173	1	101058	B8/B9	LMA	1632964	6699900			162.3	77.3	0.13380	0.01450	0.25	2,649	0.35	10454	5.9	2.7	4.9	16.9	12.3
29	PFM001180	1	101058	B8/B9	RMA	1633127	6698125			221.5	77.9	0.03097	0.00336	0.18	2,645	0.47	23206	10.3	3.2	5.6	17.9	13.8
29	PFM001183	1	101058	B8/B9	RMA	1632858	6698025			150.1	39.5	0.00993	0.00756	0.04	2,649	0.50	29889	9.2	2.8	6.3	15.8	13.1
29	PFM001213	1	101058	B8/B9	LMA	1630163	6700856			129.6	76.8	0.00530	0.00135	0.11	2,655	0.34	18277	7.6	3.0	6.5	17.4	14.0
29	PFM001213	2	101061	D2/D3	LMA	1630163	6700856												2.3	17.7	13.6	18.8
29	PFM001635	1	101058	B8/B9	RMA	1629682	6702146			95.1	76.3	0.05744	0.00921	0.14	2,650	0.36	17660	8.9	3.0	6.0	13.7	12.5
29	PFM001864	1	101058	B8/B9. -K altered	RMA	1635370	6698802			334.2	17.9	0.09754	0.00521	0.18	2,647	0.51	11498	6.9	2.9	5.7	16.5	13.0
29	PFM001867	1	101057	B8/B9	RMA	1635815	6697015			75.8	–1.3	0.00269	0.00323	0.39	2,662	0.33	28174	10.3	2.8	4.1	17.4	12.2
29	PFM001888	1	101056	C	RMA	1636321	6698886			271.6	62.0	0.00053	0.00025	0.05	2,731	0.47	6959	13.5	2.2	3.8	16.8	10.8
29	PFM005193	1	101058	B8/B9	RMA	1634961	6699251			130.8	41.4	0.10520	0.01410	0.23	2,656	0.42	18338	10.4	3.1	4.6	18.5	13.4
29	PFM005193	2	101054	C	RMA	1634961	6699251			321.7	21.0	0.00037	0.00027	0.04	2,713	0.52	16887	15.5	2.2	3.5	20.2	11.7
29	PFM005226	1	101058	B8/B9	RMA	1637182	6698116			348.3	57.9	0.01127	0.00311	0.08	2,653	0.47	8142	11.1	3.0	3.6	15.9	11.7
29	PFM005288	1	101058	B8/B9	RMA	1638048	6697002			163.6	46.1	0.04303	0.00770	0.11	2,649	0.46	21936	11.8	3.5	2.6	15.3	11.6
29	PFM005345	1	101058	C	LMA	1632115	6699372												1.8	3.2	11.3	8.2
29	PFM005599	1	101058	B8/B9	LMA	1631720	6699324												3.3	4.9	14.8	12.7
29	PFM005602	1	101058	B8/B9	LMA	1632353	6698786			69.3	54.9	0.00054	0.00017	0.10	2,659	0.34	16933	7.7	2.5	4.4	15.1	11.2
30	PFM000380	1	101053	B5/B6	RMA	1631192	6696440			303.6	56.1	0.00051	0.00033	0.04	2,753	0.32	12081	11.3	1.9	4.0	9.2	8.2
30	PFM000433	1	101053	B5/B6	RMA	1629993	6697347			215.6	64.0	0.11550	0.02753	0.12	2,674	0.47	19734	16.9	1.7	3.0	4.9	6.0
30	PFM000526	1	103076	A1	RMA	1632191	6694879			134.1	13.1	3.78500	0.07152	1.20	2,779	0.33	33765	25.3	2.6	3.0	7.6	8.2
30	PFM000557	1	101054	B5/B6	RMA	1634208	6692780			112.6	68.9	0.07266	0.00508	0.37	2,743	0.34	17168	13.6				
30	PFM000580	1	101057	B8/B9	RMA	1633155	6694140			145.7	56.0	0.00762	0.00215	0.14	2,720	0.41	14817	7.6				
30	PFM000807	7	111058	D1	RMA	1626575	6699624												4.2	14.9	20.3	22.0
30	PFM000808	1	101054	B5/B6	RMA	1626501	6699624			144.3	67.9	0.83010	0.03507	0.38	2,720	0.34	17276	13.1	1.1	3.5	7.2	6.1
30	PFM000891	1	101054	B5/B6	RMA	1627374	6699062			254.1	64.8	0.06726	0.01521	0.12	2,701	0.40	14883	16.0	2.3	2.7	10.2	8.4
30	PFM001510	1	101053	B5/B6	RMA	1632130	6695787			8.1	75.5	0.00039	0.00031	0.03	2,746	0.37	9168	9.3	2.5	3.6	11.2	9.5
30	PFM001521	1	103076	A1	RMA	1630440	6696685			113.2	80.4	2.30300	0.24000	0.24	2,946	0.40	24942	66.6	2.9	4.7	11.9	11.1
30	PFM001601	1	101056	B7	RMA	1628561	6698409			180.2	72.6	0.05621	0.00687	0.13	2,689	0.42	16962	11.9	2.2	3.6	10.2	8.7
31	PFM000240	1	103076	A1	RMA	1630884	6697370			115.7	73.2	0.79550	0.00453	0.44	2,723	0.31	58657	41.1	1.1	4.1	11.3	7.7
31	PFM000351	1	103076	A1	RMA	1631621	6696640			86.2	81.3	0.31360	0.02996	0.13	2,725	0.25	14851	14.0	1.7	4.1	10.2	8.2
31	PFM000446	1	109014	A2	RMA	1630821	6697966			71.0	3.8	79.70000	0.12220	15.90	4,130	1.47	324	200.8	0.8	6.2	5.5	6.7
31	PFM000446	2	101098	D2/D3	RMA	1630821	6697966						0.00498						2.1	18.8	10.8	18.2
31	PFM001025	1	101053	B5/B6	RMA	1635078	6693864			160.6	76.8	0.18440	0.02386	0.19	2,718	0.40	25249	18.8	1.4	1.6	5.3	4.7
31	PFM001200	1	103076	A1	RMA	1634380	6694369			269.6	75.9	0.02305	0.00053	1.74	2,717	0.20	81878	18.1	1.7	4.3	6.3	7.1
31	PFM001221	1	103076	A1	RMA	1633153	6695616			354.2	87.2	0.00070	0.00035	0.05	2,733	0.32	27650	13.8	2.0	3.2	8.5	7.6
31	PFM001221	5	103076	A1	RMA	1633153	6695616			1.4	77.6	0.38160	0.03170	0.22	2,822	0.33	47582	16.8				
31	PFM001524	1	103076	A1	RMA	1629838	6698414			3.5	79.0	0.05022	0.01986	0.20	2,700	0.30	12932	8.3	1.6	4.2	11.1	8.4
31	PFM001524	3	101061	D2/D3	RMA	1629838	6698414												3.2	36.1	19.7	33.4

Rock domain	Identity. PFM-number/ borehole	Rock unit order number	Rock type SKB code	Group	Regional or Local Model Area	East	North	Secup	Seclow	Rema-nence declina-tion [°]	Rema-nence inclina-tion [°]	Rema-nence intensity [A/m]	Volume suscepti-bility [SI]	Q-value [SI]	Wet density [kg/m³]	Porosity [%]	Electric resistivity [ohm]	Induced polarisa-tion [mrad]	K [%]	U [ppm]	Th [ppm]	Natural exposure rate [microR/h]
31	PFM001885	1	103076	A1	RMA	1632419	6696272			316.6	68.2	0.14000	0.03525	0.21	2,882	0.28	26701	27.5	1.4	2.5	4.8	5.2
31	PFM001885	2	101061	D2/D3	RMA	1632419	6696272												4.0	17.8	12.7	21.0
31	PFM002248	1	103076	A1	RMA	1633937	6695208			247.9	75.8	0.00023	0.00009	0.09	2,648	0.40	9330	8.4	3.7	3.7	12.6	11.8
32	PFM000713	1	101058	B10. -K altered	LMA	1632520	6700615			91.3	77.0	0.01935	0.00179	0.31	2,633	0.41	11467	9.4	1.4	4.1	16.4	9.7
32	PFM000713	2	101058	B8/B9. -K altered	LMA	1632520	6700615			20.2	42.0	0.00197	0.00007	0.55	2,656	0.38	15736	11.6	1.3	3.5	16.1	9.1
32	PFM000713	4	111058	D1	LMA	1632520	6700615			102.9	75.4	0.05338	0.00204	0.22	2,631	0.48	13017	12.5	4.3	9.5	33.8	22.9
32	PFM000718	3	101051	C	LMA	1632654	6700543			335.3	74.5	0.00252	0.00040	0.09	2,694	0.39	15558	14.6	1.4	5.8	11.5	9.3
32	PFM000724	2	101058	B10	LMA	1631057	6701426												2.6	7.6	21.6	15.4
32	PFM000725	1	103076	A1	LMA	1631021	6701464			15.9	21.8	0.00182	0.00020	0.20	2,695	0.37	8097	13.9	1.8	5.7	13.5	10.4
32	PFM000725	2	101098	D2/D3	LMA	1631021	6701464												3.5	25.8	18.8	27.2
32	PFM000739	1	101058	B10. -K altered	LMA	1633143	6700227			62.5	83.6	0.01948	0.00491	0.45	2,643	0.36	15961	15.9	0.8	3.3	16.0	8.3
32	PFM000739	2	101051	C	LMA	1633143	6700227			345.9	58.4	0.08236	0.01921	0.12	2,705	0.46	15740	17.6	1.2	7.5	11.3	10.0
32	PFM001623	1	101058	B10	RMA	1634042	6699909			77.4	54.0	0.04940	0.01217	0.12	2,640	0.37	18269	14.2	2.6	4.2	13.6	10.8
33	PFM001102	1	101056	C	RMA	1635649	6701738												2.9	3.3	29.2	15.4
33	PFM001102	2	101030	C	RMA	1635649	6701738												2.0	2.4	5.4	6.1
33	PFM001666	1	101058	B8/B9	RMA	1636576	6701696			165.7	45.6	0.08078	0.01704	0.12	2,654	0.43	8857	9.7	3.4	4.2	15.8	12.7
35	PFM001618	1	101098	D2/D3	RMA	1635857	6695726			16.5	46.1	0.00813	0.00267	0.52	2,622	0.62	16192	13.9	4.7	2.3	9.6	11.5
36	PFM001728	1	103086	A1	RMA	1638712	6697121			347.4	33.8	0.00063	0.00006	0.25	2,681	0.52	10560	15.3	0.5	4.1	13.0	7.4
37	PFM005237	1	101056	C	RMA	1636000	6699944			338.0	70.9	0.10710	0.02539	0.09	2,736	0.50	10860	16.4	2.0	2.3	12.7	8.3
38	PFM005196	1	101054	C	RMA	1637475	6699859			350.3	31.9	0.05840	0.01619	0.09	2,743	0.55	13102	15.9	1.5	3.2	11.6	7.9
39	PFM001682	1	101058	B10	RMA	1635604	6701523			71.5	57.4	0.03716	0.00710	0.08	2,630	0.38	14064	8.6	4.0	5.1	19.8	15.4
41	PFM001094	1	101056	C	RMA	1636051	6702598												1.7	4.9	25.1	13.4
41	PFM001094	2	108017	A1	RMA	1636051	6702598			143.0	64.8	0.00049	0.00270		2,691	0.48	10888	15.9	1.3	5.3	12.8	9.2