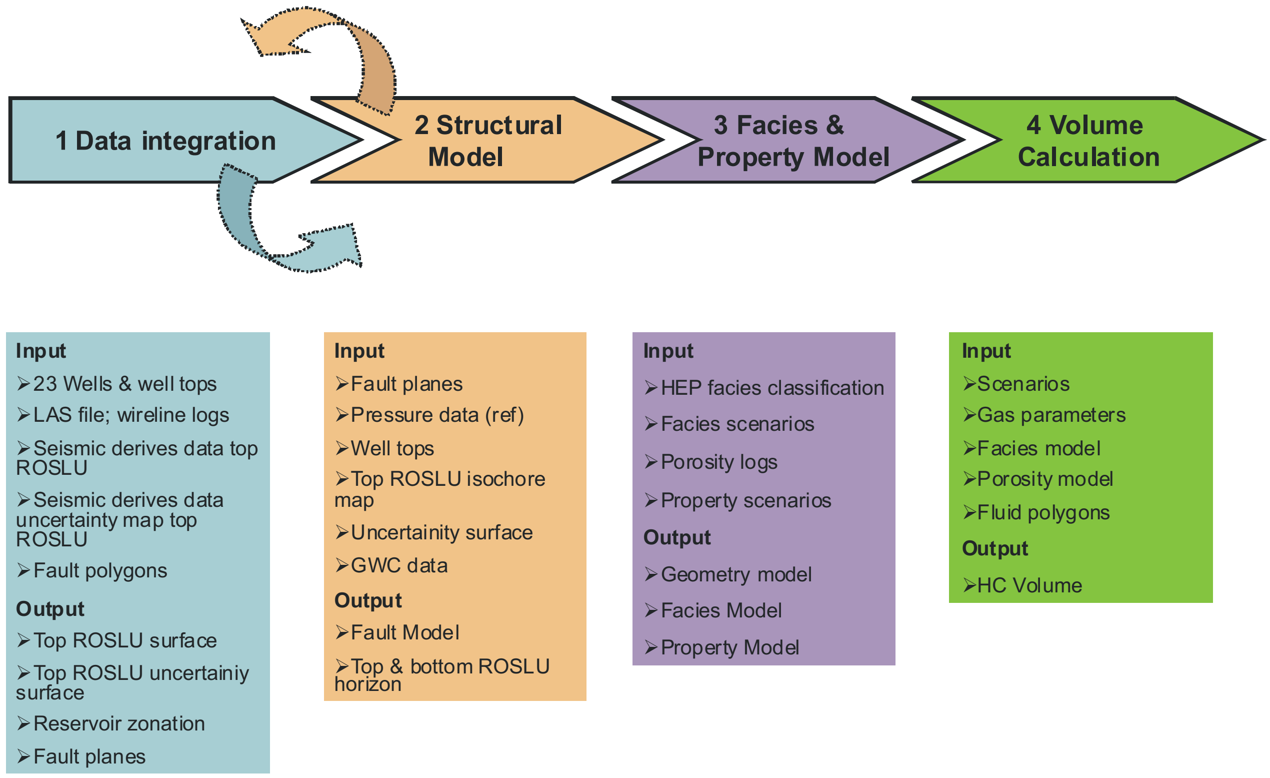

Figure 4-1 3D modelling workflow applied on Bergermeer, Groet and Bergen Fields

Workflow divided into four parts; data integration, structural model (section 4.4.1and 4.4.2), facies & property model (section 4.4.3 and 4.4.4), and volume calculation (section 4.4.7).

4.3 Data QC & Processing

4.3.1 Surface & Faults

There were several quality controls introduced in the Bergermeer project. These controls were made in order to constrain the 3D static modelling of Bergermeer project, such as:

- Creating 14 help data as Top ROSLU well tops (section 4.4.2)
- Remove the Top Weissliegend (section 2.1.1)
- Remove fault 9 occurrence (section 4.4.1)
- Smoothing the Top ROSLU horizon (10x, see section 4.4.2)
- Creating new 3D grid model named “BGMwithoutBGM8” as QC model (section 4.4.3)

Each of the QC’s will be explained separately in this report relevant to each sub-chapter.

4.4 Static Modelling

4.4.1 Fault Model and Pillar Gridding

Fault polygons, as provided by Taqa, were loaded for the positioning of the faults (Figure 4-2). In total, 17 faults are available as an active fault (offset/throw occurrence).

Fault directions (strike) from three fields are NW-SE, approximately. Fault dip angles are in NE and SW direction. In Bergermeer and Groet Fields (main project area), dip angles were fitted as well as possible. But in Bergen Field, dip angles were fit for purpose (locally verticalized).

The pressure observations in the field show that the BGM7 well experiences a regime different from the rest of the wells (see chapter 5). Therefore, it is a modelling requirement to have a fault physically included. In the process of the project several alternatives have been discussed (as we will see later in the dynamic modelling chapter). Initially, we assigned a non-active fault (no offset) called 'Fault 2b', whose direction was assumed parallel to fault 3 and fault 15, i.e. broadly speaking bending towards the west. Later different alternatives have been modelled. The main one is a more or less linear extension of 'fault 2a'. The structural context (section 2.1.4) does not unambiguously identify a preferred scenario, although there are some arguments for the latter.

Similarly, as we will see in chapter 5, it is not possible to achieve a match without some sort of baffle hindering the free fluid flow between Bergermeer and Groet. As discussed in section 2.1.4, the transfer zone between Bergermeer and Groet could likely be affected by sub-seismic faulting. Therefore we resolved this issue by the introduction of a fault across the spill-point.

These alternative 'fault2' extensions, as well as the spill-point fault, were introduced directly into the simulation model (in Petrel), and will be discussed in more detail in chapter 5. The reason for this is that the faults are notional anyway, and introducing them *post facto* into the grid leaves the grid unchanged, and is thus less work. It is important to emphasize that, although they were added in a history matching context, this happened in consultation & agreement with the geologists.

For dynamic modelling purposes, HEP divided the model into several segments. This required additional separation by creating two non-active faults; fault 18 and fault 19 (Table 4-2). The segments also help in horizon construction, for better constraining the interpolation.

On the contrary, fault 9 which is located in the west of Groet Field is excluded from the modelling area. The distance between fault 9 and fault 10 is too close (Figure 4-6), creating poor grid. Poor grid requires longer computing time in flow modelling simulation. Hence, fault 9 is located outside Bergermeer project (west of Groet Field).

Faults (active and non-active) in the modelling area were assigned as the project boundary and segment boundary. The J-trends (Y direction) of the grid parallel to NW-SE striking faults. Several I-trends (X directions) were created manually as a line perpendicular to J-trends, approximately (Figure 4-7). It is recommended for dynamic modelling simulation to have an equal grid blocks size to reduce the computing time.

Initially, the grid was generated using a horizontal resolution of the grid block dimension 50*50 meters. Because of the facies model in the project area appears not complex, HEP reduced the resolution of the grid block dimension to 100*100 meters.

4.4.2 Top and Base reservoir, Zonation and Layering

The Top ROSLU's (= top reservoir) structure surface of the modelling area as provided by Taqa, was used as a template surface for the creation of the structural model of the Bergermeer Field and surrounding. Together with Top ROSLU's well top and 14 help data points (pseudo well tops refer Table 4-3), Top ROSLU horizon was generated.

For the Top ROSLU horizon, ten times smoothing was done in order to constrain the QC of the reservoir surface map as fit as the input data as provided by Taqa This QC removed surface peaks (bumps) as a result of seismic artefacts in the reservoir are; many 'bumps' in this surfaces have little vertical consistency and do not really reflect geological patterns (Figure 4-15).

The Top DCCR's structure surface was created by isochoring down using a regional Rotliegend thickness map provided by TAQA (on average about 252 m over the AOI, Figure 4-19) It was then re-gridded to tie it into the two available DCCR well tops (section 2.2). The intersection between BER1 (whose DCCR top was not used; see section 2.2) and the top DCCR horizon is about 5m shallower than this BER1 pick, providing a useful cross-check on the accuracy on the isochoring technique.

Several help points needed to be re-introduced to avoid general distortion and constrain the spillpoint structure (-2230 meters MD) between Bergermeer and Groet (Figure 4-16 and Figure 4-17). [It should be noted that the spillpoint was already introduced explicitly in the Taqa Time-Depth conversion.]

The influence radius of the wells was set to infinity honouring the data points; we used 'well adjustment inside segment only'. Petrel's *convergent gridding* algorithm was used to close the gap towards the faults. A general blanking distance (up to 300 meters) (Figure 4-14) on each side of the faults was assigned in order to correct the seismic inaccuracy in proximity of faults.

It was chosen to use only one zone (see section 2.2), named "Rotliegend", extending from the Top ROSLU to the Top DCCR.

The layering scheme "proportional to base" was chosen a vertical grid of 150 layers with an average 1.68 meters thickness was generated (Figure 4-23).

All in all, the Petrel model of Bergermeer contains Nx=58 cells, Ny=182 cells, totalling of 1.6e6 cells.

4.4.3 Facies Modelling

The objectives of the facies modelling are to capture heterogeneity and better constrain the property distribution of the porosity within reservoir zone. We can observe three trends from the logs:

- A possible areal trend: lower porosities in GRT than in BGM. [Since the two sets of wells are rather narrowly grouped, this trend is not very well covered.]

- 10's of m scale vertical trend showing good porosities in the C of the Rotliegendes, less good at the top & base.
- Small-scale (m) poor streaks.

The former two are correlatable. However, from the available data (cores, thin sections, logs) no clear picture emerged (see chapter 2) as to the nature of the heterogeneities, in particular the low-porosity streaks visible throughout the reservoir section. The low-porosity streaks could also not be deterministically correlated (contrary to the larger scale 'bell' shape trend). As a consequence, there is no clear-cut way to propagate these properties into a 3D property model. Given the overall goal of the project, we decided to instead develop several scenarios, where the main parameter is being varied is the continuity of the streaks: from long (compared to inter-well distance) to short.

This facies modelling process starts by distinguishing good porosity (background) and the low porosity streaks (main heterogeneities) from the well logs. The facies were visually picked by comparing the actual response of the logs, in particular the density log, relative to the overall larger scale 'bell' density trend. In this way, a continuous facies log was 'painted' for all wells.

Upscaling of the facies logs (from wells to static model cells) was done applying "most of" as an average method with the weighted of 1.0 for background facies (good porosity) and 1.10 for poor streaks facies (low porosity) in order to avoid losing the thinner low porosity streaks.

A 3D facies property was created for the Rotliegend zone and was carried out and modelled using variogram analysis and stochastic interpolation. The facies geometry was assigned as an generic ellipse body due to the lack of knowledge about the nature of the poor streaks.

Three different facies models were created for the Bergermeer project. In the first scenario is assumed that the low porosity streaks are discontinuous (extent 150 to 300 meters). The second scenario assumed that some low porosity streaks are continuous (extent 250 to 1200 meters) while others are not. The last scenario assumed that the low porosity streaks are continuous over distances that are large compared to the inter-well distance (extent 4500 to 13500 meters). It should be noted that the latter is certainly an overestimation given the lack of correlatability of the poor streaks (Figure 4-27). These facies modelling scenarios are shown in Figure 4-24 to Figure 4-26.

The same facies model scenarios were also applied for low case and high case 3D grid model uncertainty.

As a QC, we ran the workflow without BGM8A (i.e. with BGM8A as a 'blind well') and the appearance of features in the 3D model doesn't change significantly; well BGM8A was qualitatively well captured (Figure 4-28).

4.4.4 Property Modelling

4.4.4.1 Porosity Modelling

The PHIE_HEP log (as discussed in section 3.3) was used as input. *Upscaling* of these porosity logs to geomodel cells was done applying arithmetic averaging. The resulting upscaled logs were compared to the raw (original) data logs (Figure 4-10 and Figure 4-40) to make sure that the statistics of the model honour the input data, and that the main heterogeneities (low porosity streaks) are captured.

Based on the upscaled cells, a full 3D property cube is constructed via geostatistical methods. For all scenarios, HEP used a 1D-trend; "bell" curve-shape, to constrain the population of the property set of the good porosity and low porosity streaks based on the PHIE_HEP and facies cross plot (Figure 4-32), to ensure that the observed overall vertical porosity trend (good in the middle, worse in the top and base) is honoured by the 3D model. To ensure that the model is appropriately heterogeneous, the porosity cube population is conditional on the facies cube (section 4.4.3): the 'low porosity streaks' facies are populated separately from the 'good' background. These 'poor' streaks have lower porosities offset from the overall 1D trend.

Analogously to the facies modelling, multiple porosity models were developed , intending to capture the range of porosity correlation lengths. These were combined with the facies models discussed above. In total five different porosity+facies models were constructed for the Bergermeer project. The porosity/facies combinations used are outlined in Table 4-8. The major and minor directions for facies and porosity variograms are aligned. The first scenario combines 'discontinuous poor streaks' with a porosity variogram range of 300 meters. The second until the fourth scenarios are combine a 'mid' poor streak scenario with the porosity variogram ranges of 500 meters, 1500 meters and 3000 metres. The final scenario combines the 'continuous poor streak' facies case with a 5000 metre porosity variogram (Table 4-8).

With these porosity/facies continuity scenarios we cover a fairly wide range of possible subsurface properties (Figure 4-36 until Figure 4-39). As a QC, the upscaled porosity log and the property (porosity) population in all scenarios have the similar mean and standard deviation value (match between upscaled and 3D model, details Table 4-10). However, looking at the statistics of the various variations, we see that the trends in the model express themselves in different degrees. No trends were explicitly forced upon the model. The exception is the 'bell' porosity profile discussed above. The correlation coefficient used for this is quite low however (Figure 4-33). In models with long variogram ranges (compared to interwell distances), the areal and vertical trends are 'automatically' forced (to a fault), in models with short variogram ranges the trends will be less pronounced or absent. This is exactly what happens (Figure 4-34). Thus the various scenarios also differ in vertical and areal trends. As regards the areal trend, this is not such a large problem, since the permeability model is based on BGM data only, and since the permeabilities will be matched on a per-field basis (chapter 5). For the vertical permeability profile this is an issue, and in chapter 5 we will investigate adhoc imposition of a bell profile into a model that does not have it naturally.

4.4.4.2 Permeability Modelling

Permeability was computed from porosity by employing the core-derived relation (section3.4.2) to the model cells (i.e. not to the well logs). This is simpler, and the uncertainties are taken to be bigger than the error potentially made here (because of the scale difference between cores, logs and geomodel cells). No explicit PERMZ cube was generated; the PERMZ/PERMH difference comes in through the upscaling to flow simulation cells (see next section). In as far as the direct application of the por/perm correlation leads to overestimation of the PERMZ/PERMH ratio, this will be captured by a PERMZ multiplier in the flow simulation (chapter 5).

4.4.5 Property upscaling to the simulation model

The following upscaling algorithms were used in the upscaling of properties on the simulation grid from the static model grid:

- Porosity: Arithmetic
- Permeability: 'Tensor'
- Facies (where used): 'Most Of'

Figure 4-45, Figure 4-46 show the main settings, as well as relevant QC histograms for the most-used case ('continuous facies', 'mid' porosity variogram). Key aspects of the results of this process step will be discussed in more detail in chapter 5.

4.4.6 Structural Sensitivities

An uncertainty map for the top Rotliegend was provided by Taqa (Figure 4-12). It should be noted that this map is not always positive, nor is it zero at the well locations.

The *absolute* value of the provided map was added and subtracted from the reference case top Rotliegend horizon. This yielded two additional different top horizons. These were force-tied to the well tops (Figure 4-22). Since the input uncertainty map is not zero at the wells, this well-tieing will mean non-zero shifts, so that the "high" case is below the reference case in some places, and the "low" case above.

Combining these three top horizons, with the reference base horizon, we generate two additional 3D grid model scenarios namely "Bergermeer100_HighCase" and "Bergermeer100_Low Case". Isochore map QCs are plotted in Figure 4-19 and Figure 4-20. The property workflows as outlined above were run for all three 3D grids.

4.4.7 Volume Calculation

The volumetrics of the Bergermeer modelling area was calculated using different gas parameter such as N/G (net to gross), porosity calculated (section 4.4.4.1) for the five different porosity modelling scenarios (Table 4-8), Sg (gas saturation) and Bg (bulk gas) (see Table 4-12), leading to volumetrics as reported in Table 4-13. Thus, we end up with volumes between 16.1E6 Sm3 and 16.9E6 Sm3. The volumetrics in the high and low case model are also shown in Table 4-13.

It should be noted that the volumes will be corrected adhoc in the simulation model (because the pressure history match is mostly volumetrically driven; chapter 5). As we shall see the base case volumes found are somewhat too low for BGM. The reason for this is not clear; possibly the high-case structure is closer too reality. Alternately, the porosity and/or water saturation values could be too pessimistic.

Table 4-1 **Use of well data for facies and property distribution ('Properties'), and for structural modelling ('Structure')**

Well Name	Well path	LAS file	Structure		Properties	
			well top ROSLU	well top DCCR	Facies	Property
BGM 1	√	√	√		√	√
BGM 2	√	√	√		√	√
BGM 3	√	√	√		√	√
BGM 3A	√		√			
BGM 4	√	√	√		√	√
BGM 5	√	√	√		√	√
BGM 6	√	√	√			
BGM 6A	√	√	√			
BGM 7	√	√	√	√	√	√
BGM 8A	√	√	√	√	√	√
BGM 9	√	√				
GRT 1	√	√	√		√	√
GRT 2	√	√	√		√	√
GRT 3	√	√	√		√	√
GRT 3A	√	√	√		√	√
GRT 4	√	√	√		√	√
GRT 5	√	√	√		√	√
GRT 6	√	√	√			
GRT 7	√	√	√		√	√
BER 1	√	√	√	X		
BER 2	√	√	√		√	
BER 3	√	√	√		√	√
BER 4	√	√	√			

Table 4-2 List of faults used for pillar gridding.

Fault 2b is separating between BGM7 and other wells in Bergermeer. The pressure data showed BGM7 well has different pressure data from the rest of the wells. Therefore it is a modelling requirement to have fault physically included (no offset = non-active). Fault 9 is excluded based on longer computing time in flow simulation problem towards unequal grid block. Hence, fault 9 is not the project area. Fault 18 and fault 19 were created for segment separation purposes and should be set as non-active faults (no offset).

Field	Fault Name	
Bergermeer	Fault 1	√
	Fault 2a	√
	Fault 2b	non-active
	Fault 3	√
	Fault 4	√
	Fault 5	√
	Fault 6	√
	Fault 7	√
	Fault 20	√
Groet	Fault 8	√
	Fault 9	excluded

Field	Fault Name	
Groet	Fault 10	√
Bergen	Fault 11	√
	Fault 12	√
	Fault 13	√
	Fault 14	√
	Fault 15	√
	Fault 16	√
	Fault 17	√
	Fault 18	non-active
	Fault 19	non-active

Table 4-3 **List of the help data points (pseudo well tops) constraining the 'Make Horizons' process for the Top ROSLU (=Top Reservoir) horizon.**

	Well	Surface	X	Y	Z	Used by Dep.Conv.	Used by Geo Mod
69	Help_data_ROSLU	Top ROSLU	105723.2	521450.4	-2242.47	1	1
70	Help_data_ROSLU	Top ROSLU	106994.9	519136.8	-2413.83	1	1
71	Help_data_ROSLU	Top ROSLU	109202.7	518433.3	-2087.79	1	1
72	Help_data_ROSLU	Top ROSLU	109210.4	518334.5	-2079.14	1	1
73	Help_data_ROSLU	Top ROSLU	108116.2	519124.4	-2175.5	1	1
74	Help_data_ROSLU	Top ROSLU	110732.5	517565.1	-2129.97	1	1
75	Help_data_ROSLU	Top ROSLU	110190.2	517674	-2100.66	1	1
76	Help_data_ROSLU	Top ROSLU	110040.9	517420.3	-2044.74	1	1
77	Help_data_ROSLU	Top ROSLU	109773.2	517423.8	-2065.38	1	1
78	Help_data_ROSLU	Top ROSLU	109354.3	518102.3	-2072.96	1	1
79	Help_data_ROSLU	Top ROSLU	110320.3	517498.5	-2078.84	1	1
81	Help_data_ROSLU	Top ROSLU	106436.7	523322.7	-2230.59	1	1
82	Help_data_ROSLU	Top ROSLU	107589.9	521187.3	-2199	1	1
83	Help_data_ROSLU	Top ROSLU	106826.1	522311	-2220.92	1	1

Table 4-4 Well report from making the horizon

"Horizon after" is the depth (MD) of the horizon surface intersection with the well; "different after" is the difference to the corresponding well top.

Well report for 'Bergermeer100/Isochore_trend100' (Done in the Make Horizons process)

Top ROSLU	Well	Missing	Md	X-value	Y-value	Z-value	Horizon befo	Diff before	Horizon after	Diff after
	GRT1	No	2508	104585.9	525907.1	-2038.06	-2046.74	8.69	-2038.06	0
	GRT2	No	3756	102534.6	527427.9	-2260.92	-2250.22	-10.7	-2260.92	0
	GRT3	No	2454	104380	524975.6	-2215.07	-2214.72	-0.35	-2215.07	0
	GRT3A	No	2254	104528.1	525327.9	-2120.5	-2123.9	3.4	-2120.5	0
	GRT4	No	2600	103889	526786.3	-2109.37	-2112.04	2.67	-2109.37	0
	GRT5	No	2623	105101.9	525907.1	-2559.22	-2559.98	0.76	-2559.22	0
	GRT6	No	2310	104140.6	526157	-2104.4	-2099.37	-5.04	-2104.4	0
	GRT7	No	2826	105974.4	525779.1	-2443.74	-2443.47	-0.27	-2443.73	0
	BER1	No	2511	105409.6	520209.5	-2097.78	-2101.91	4.13	-2097.78	0
	BER2	No	2555	104816.9	521277.9	-2019.12	-2030.16	11.05	-2019.12	0
	BER3	No	2835	104173.1	521880.9	-2028.72	-2032.63	3.91	-2028.72	0
	BER4	No	2573.25	104364.5	521498.8	-2019.07	-2016.36	-2.71	-2019.07	0
	BGM1	No	2079.5	109635.1	518322.1	-2073.8	-2101.12	27.32	-2073.8	0
	BGM2	No	2481.5	110362.4	517323.1	-2116.51	-2119.87	3.36	-2116.51	0
	BGM3	No	2905.5	108571.2	519590.3	-2204.85	-2193.67	-11.18	-2204.85	0
	BGM3A	No	2569	109002.6	519097.3	-2163.35	-2168.71	5.36	-2163.35	0
	BGM4	No	3287	110481.2	516443.4	-2271.15	-2265.36	-5.79	-2271.15	0
	BGM5	No	2228	109883.2	517946.1	-2094.91	-2093.45	-1.46	-2094.91	0
	BGM6	No	2344	109061.1	518428.4	-2228.79	-2315	86.21	-2228.79	0
	BGM6A	No	2205.5	109339.7	518702.1	-2090.4	-2124.13	33.73	-2090.4	0
	BGM7	No	3171.25	108220	519654	-2194.64	-2188.82	-5.82	-2194.64	0
	BGM8A	No	2125	109598	518038	-2069.26	-2068.21	-1.05	-2069.26	0
	Help_data_ROSLU	No	0	105723.2	521450.4	-2242.47	-2245.36	2.89	-2242.47	0
	Help_data_ROSLU	No	0	106994.9	519136.8	-2413.83	-2419.6	5.77	-2413.83	0
	Help_data_ROSLU	No	0	109202.7	518433.3	-2087.79	-2105.61	17.81	-2087.79	0
	Help_data_ROSLU	No	0	109210.4	518334.5	-2079.14	-2091.86	12.72	-2079.14	0
	Help_data_ROSLU	No	0	108116.2	519124.4	-2175.5	-2154.68	-20.82	-2175.5	0
	Help_data_ROSLU	No	0	110732.5	517565.1	-2129.97	-2146.2	16.23	-2129.97	0
	Help_data_ROSLU	No	0	110190.2	517674	-2100.66	-2112.71	12.05	-2100.66	0
	Help_data_ROSLU	No	0	110040.9	517420.3	-2044.74	-2090.96	46.22	-2044.74	0
	Help_data_ROSLU	No	0	109773.2	517423.8	-2065.38	-2070.88	5.5	-2065.37	0
	Help_data_ROSLU	No	0	109354.3	518102.3	-2072.96	-2057.74	-15.21	-2072.96	0
	Help_data_ROSLU	No	0	110320.3	517498.5	-2078.84	-2121.37	42.53	-2078.84	0
	Help_data_ROSLU	No	0	106436.7	523322.7	-2230.59	-2217.09	-13.5	-2230.59	0
	Help_data_ROSLU	No	0	107589.9	521187.2	-2199	-2198.81	-0.19	-2199	0
	Help_data_ROSLU	No	0	106826.1	522311	-2220.92	-2218.29	-2.64	-2220.92	0

Top DCCR	Well	Missing	Md	X-value	Y-value	Z-value	Horizon befo	Diff before	Horizon after	Diff after
	BGM1	No	2296.13	109633	518314.1	-2290.27	-2300.37	10.1	-2290.27	0
	BGM8A	No	2318.86	109585.7	518037.6	-2262.73	-2284.85	22.12	-2262.73	0

Table 4-5 Geometry setting used for the low porosity streaks in the modelling area
The orientation of the porosity streaks is based on the minimum, mean and maximum value of the dipmeter value in BGM2 (see Table 4-6). The thickness of the low porosity streaks are based on the facies logs reading. The minor width of the three different facies scenarios are meant to bracket, rather overestimate than underestimate, the range of the possibilities.

	Min	Med/Mean	Max/Std
Orientation	45	200	270
Major/Minor Ratio	0.8	1	1.2
Thickness	0.6	7	20
	Minor Width		
	Min	Med/Mean	Max/Std
discontinuous	150	250	300
mid	250	600	1200
continuous	4500	9000	13500

Table 4-6 Dip/azi values from BGM2 dipmeter log

depth	dip	azimuth
2484	37	270
2485	44	225
2489	29	190
2494	34	190
2496	27	200
2500	26	260
2503	33	190
2504	21	225
2505	13	270
2510	26	225
2512	9	225
2514	15	190
2517	21	185
2522	29	260
2523	19	220

depth	dip	azimuth
2534	41	225
2539	29	265
2541	15	230
2542	16	230
2554	8	135
2571	11	45
2576	26	135
2599	17	180
2604	24	225
2610	14	225
2614	14	90
2616	20	135
2652	29	225
2655	24	225
2656	8	180

	azimuth	dip
min	45	8
average	202.5	22.63333
median	225	22.5
max	270	44
std	52.22217	9.586209

Table 4-7 **Facies modelling statistics result of low porosity streaks for different scenarios. Type of facies is discontinuous, either good porosity (0) or low porosity streaks (1). Therefore, mean value is not available. Number of defined value (N) for well logs and upscaled based on 1D well sample data point, and property based on 3D (more points). No filtered assigned for facies modelling.**

Statistics for discontinous [U] (Unfiltered)									
Name	Type	Min	Max	Delta	N	Mean	Std	Var	Sum
Property	Disc.	0	1	1	1187244	0	0	0	208133
Upscaled	Disc.	0	1	1	1335	0	0	0	234
Well logs	Disc.	0	1	1	1334	0	0	0	238

Statistics for Mid [U] (Unfiltered)									
Name	Type	Min	Max	Delta	N	Mean	Std	Var	Sum
Property	Disc.	0	1	1	1187244	0	0	0	208192
Upscaled	Disc.	0	1	1	1335	0	0	0	234
Well logs	Disc.	0	1	1	1334	0	0	0	238

Statistics for continous [U] (Unfiltered)									
Name	Type	Min	Max	Delta	N	Mean	Std	Var	Sum
Property	Disc.	0	1	1	1187244	0	0	0	214443
Upscaled	Disc.	0	1	1	1335	0	0	0	234
Well logs	Disc.	0	1	1	1334	0	0	0	238

Table 4-8 Property (porosity) modelling scenarios in the modelling area. Parameter combinations were chosen to emphasize the range (Table 4-9); nomenclature refers to the porosity variogram length *relative* to the poor streak body size..

Low Porosity Streak Facies Scenarios				
Continuous [9000m]			'continuous mid'	
mid 600m	'mid low'	'mid mid'	'mid high'	
Discontinuous [250m]	'discontinuous mid'			
	300-500m	**1500m**	**3000m-5000m**	**Lateral porosity variogram range**

Table 4-9 Variogram setting used for property modelling; All units are in meter, except azimuth (degree).

Low Porosity Streaks Scenario	Major-Minor Direction	Vertical	Azimuth
Discontinous-mid	300-300	5	0
mid-low	500-500	5	0
mid-mid	1500-1500	5	0
mid-high	3000-3000	5	0
Continous-mid	5000-5000	5	0

Table 4-10 Property modelling statistics results of five different low porosity streaks scenarios in the modelling area of Bergermeer, Groet and Bergen Fields
Property type is varies (continuous) between 3-39% upscaled porosity. Mean and Standard deviation (Std) of 3D property are match with the 1D upscaled value.

Statistics for PHIE_discontinous_midR [U] (Unfiltered)									
Name	Type	Min	Max	Delta	N	Mean	Std	Var	Sum
Property	Cont.	0.03	0.39	0.35	118724 4	0.19	0.06	0	224929.3
Upscaled	Cont.	0.03	0.39	0.35	1260	0.19	0.06	0	238.36
Well logs	Cont.	0	0.4	0.4	8893	0.18	0.06	0	1642.65

Statistics for PHIE_mid_lowR [U] (Unfiltered)									
Name	Type	Min	Max	Delta	N	Mean	Std	Var	Sum
Property	Cont.	0.03	0.39	0.35	118724 4	0.19	0.06	0	225982.56
Upscaled	Cont.	0.03	0.39	0.35	1260	0.19	0.06	0	238.36
Well logs	Cont.	0	0.4	0.4	8893	0.18	0.06	0	1642.65

Statistics for PHIE_mid_midR [U] (Unfiltered)									
Name	Type	Min	Max	Delta	N	Mean	Std	Var	Sum
Property	Cont.	0.03	0.39	0.35	118724 4	0.19	0.06	0	224441.1
Upscaled	Cont.	0.03	0.39	0.35	1260	0.19	0.06	0	238.36
Well logs	Cont.	0	0.4	0.4	8893	0.18	0.06	0	1642.65

Statistics for PHIE_mid_highR [U] (Unfiltered)									
Name	Type	Min	Max	Delta	N	Mean	Std	Var	Sum
Property	Cont.	0.03	0.39	0.35	118724 4	0.19	0.06	0	223745.21
Upscaled	Cont.	0.03	0.39	0.35	1260	0.19	0.06	0	238.36
Well logs	Cont.	0	0.4	0.4	8893	0.18	0.06	0	1642.65

Table 4-11 List of gas water contact (GWC) per segment in the modelling area of Bergermeer, Groet and Bergen Fields (cf. Figure 4-41).

segment	depth
segment 1	-2217
segment 2	-2217
segment 3	-2228
segment 4	-2150
segment 5	-2217

segment	depth
segment 6	-2228
segment 7	-2150
segment 8	-2120
segment 9	-2228
segment 10	-2150

segment	depth
segment 11	-2228
segment 12	-2150
segment 13	-2228

Table 4-12 Volume calculation parameter used for different scenarios

N/G	0.995
Sg	0.8
Bg	0.0047

Table 4-13 GIIP volumetric results

Por/facies scenarios as in Table 4-8. The ‘fault2’ trace used is the west-trending one, which gives too-low BGM7 volumes (see chapter 5).

Bergermeer100 midcase

Scenario	BGM main [*10^6 sm3]	BGM_7 [*10^6 sm3]	Groet [*10^6 sm3]	Bergen [*10^6 sm3]	Total [*10^6 sm3]
discontinous	14182	1988	13394	23087	52651
mid-low	14470	1843	13143	22894	52350
mid-mid	14313	1849	10415	10830	37407
mid-high	14371	1771	11814	22907	50863
continous	14954	1938	9928	10736	37555

Bergermeer100_LowCase

Scenario	BGM main [*10^6 sm3]	BGM_7 [*10^6 sm3]	Groet [*10^6 sm3]	Bergen [*10^6 sm3]	Total [*10^6 sm3]
discontinous	9890	1349	12196	22546	45981
mid-low	10146	1377	11910	22305	45738
mid-mid	10165	1253	10913	21786	44117
mid-high	10209	1185	10699	22796	44889
continous	10544	1087	10615	22350	44596

Bergermeer100_HighCase

Scenario	BGM main [*10^6 sm3]	BGM_7 [*10^6 sm3]	Groet [*10^6 sm3]	Bergen [*10^6 sm3]	Total [*10^6 sm3]
discontinous	18095	3079	12137	12799	46110
mid-low	18429	3106	14153	25358	61046
mid-mid	18353	3011	13183	25257	59804
mid-high	18845	2968	12808	24675	59296
continous	18990	2888	10819	12627	45324

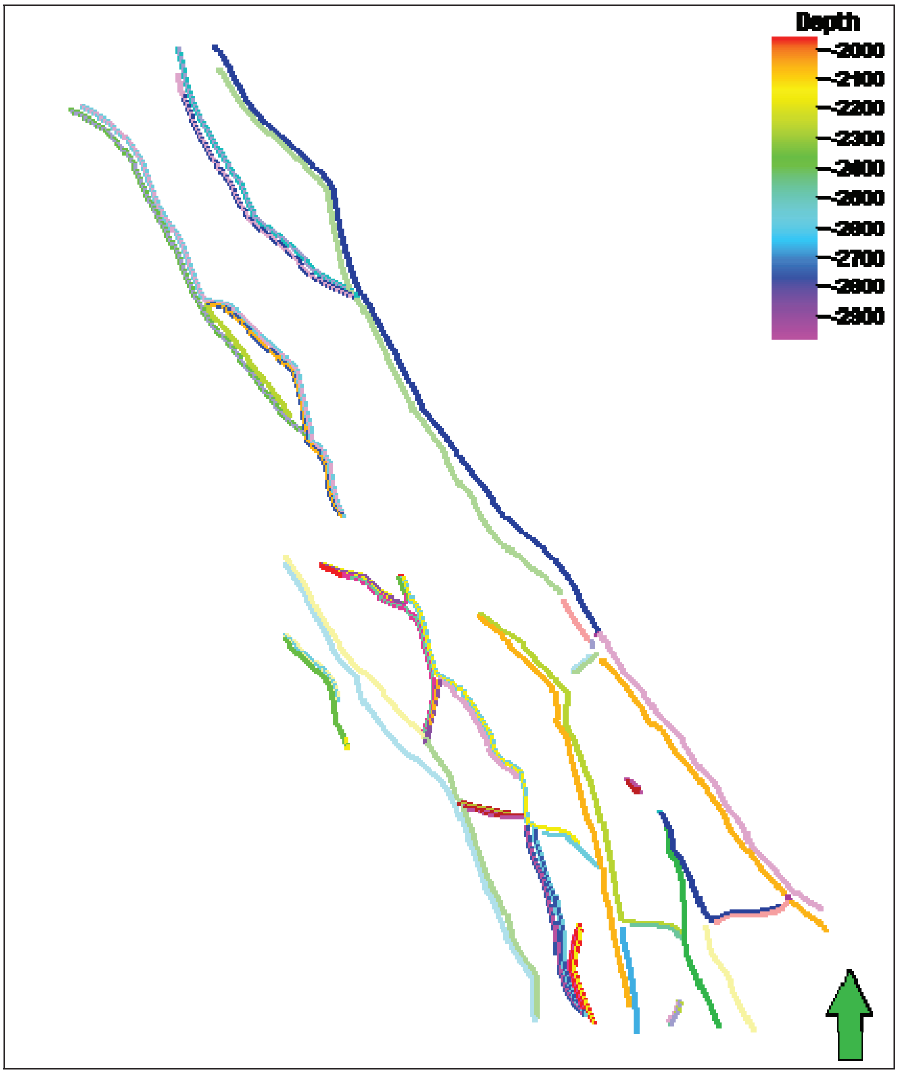

Figure 4-2 Fault Polygons in the modelling area

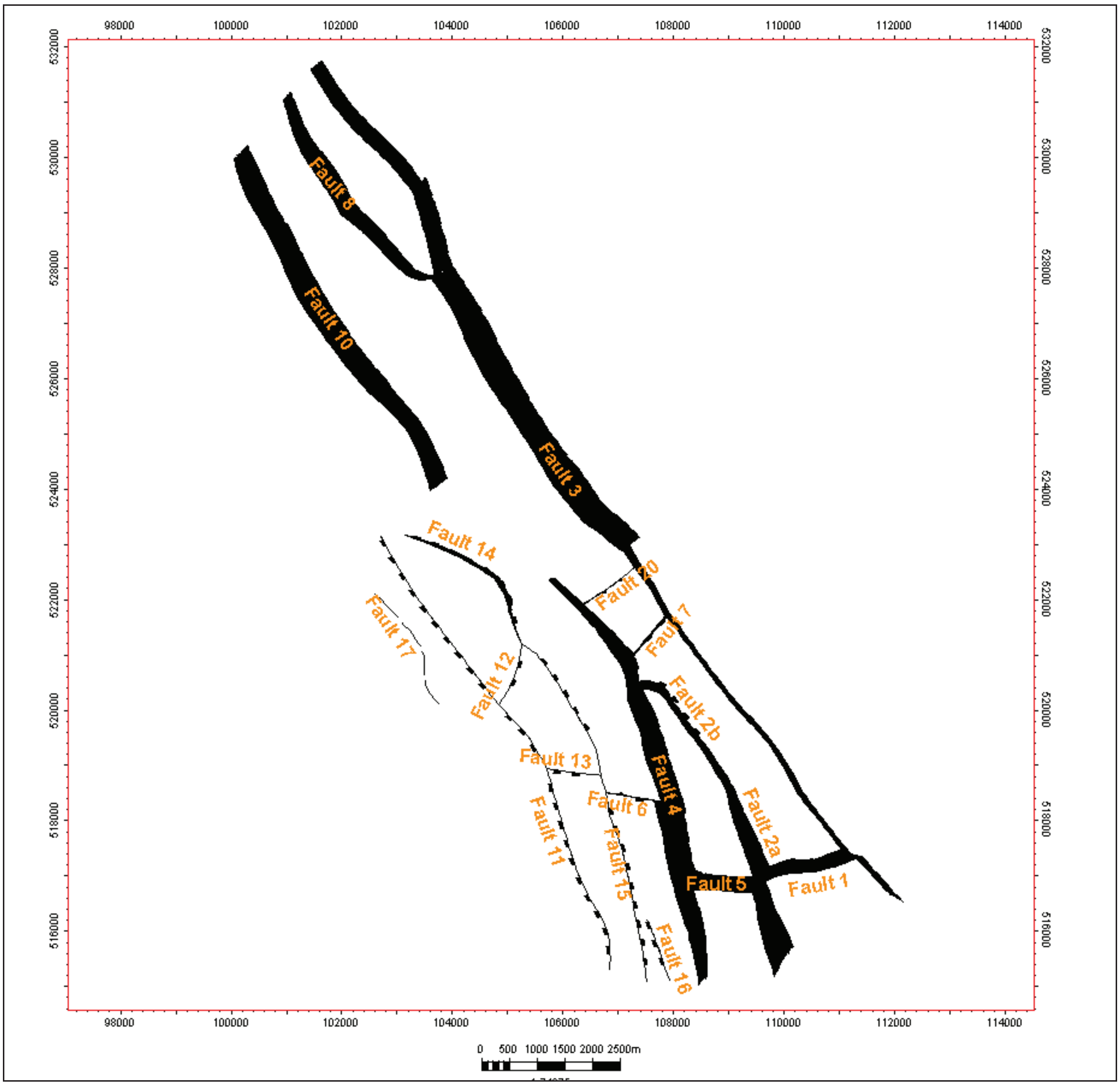

Figure 4-3 Faults setting and overview in the Bergermeer, Groet and Bergen modelling area

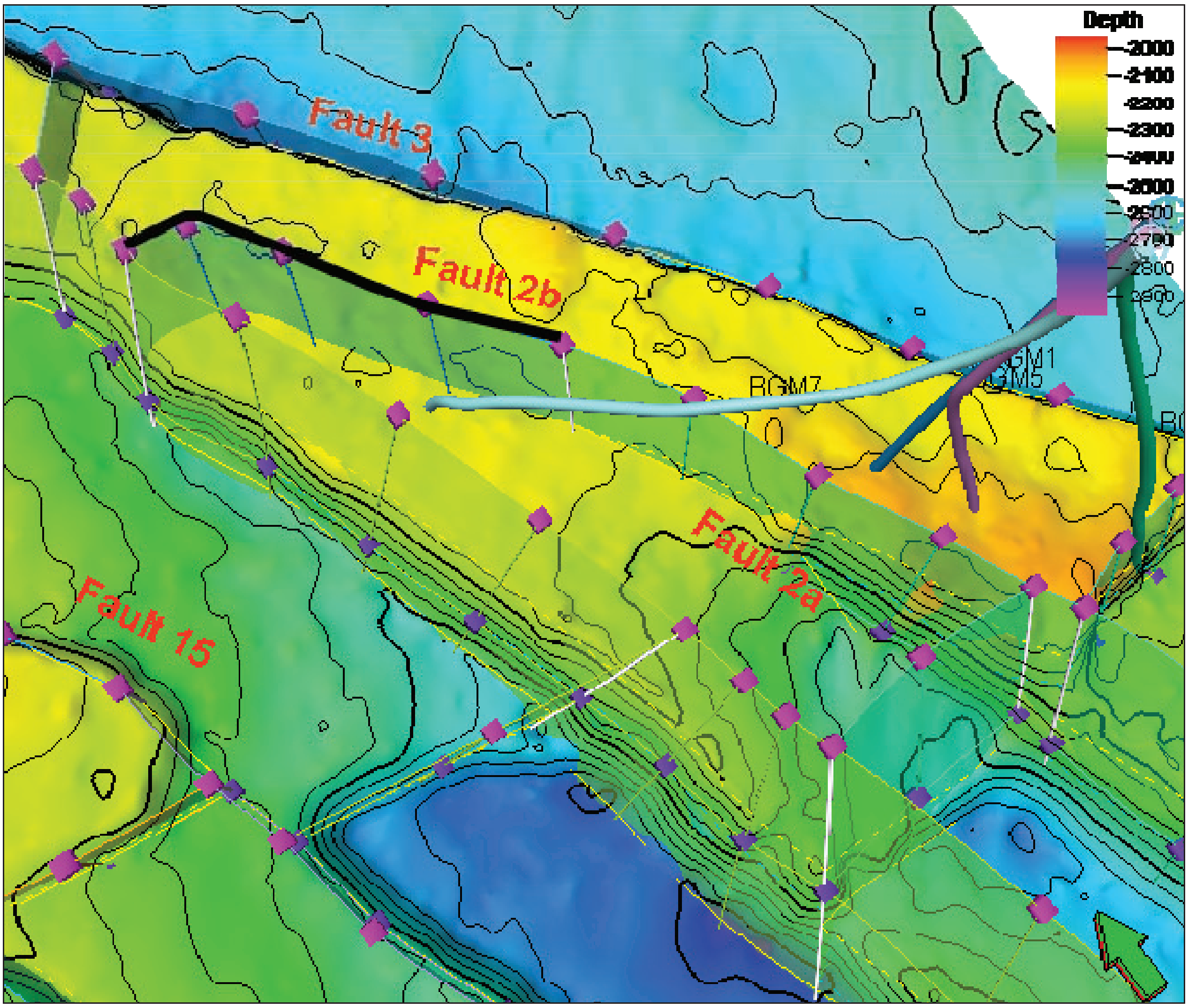

Figure 4-4 Fault 2b interprets as extended fault 2a.

Although seismic evidence is not present but based on different pressure between BGM7 and other wells in the Bergermeer Field, it is necessary to insert fault 2b in the modelling area. There is no facies change in the surrounding area. The direction of the fault 2b interpretation based on the parallel fault (fault 3 & fault 15) that appeared in the same directions. For further faults setting in the modelling area refer to Figure 4-3

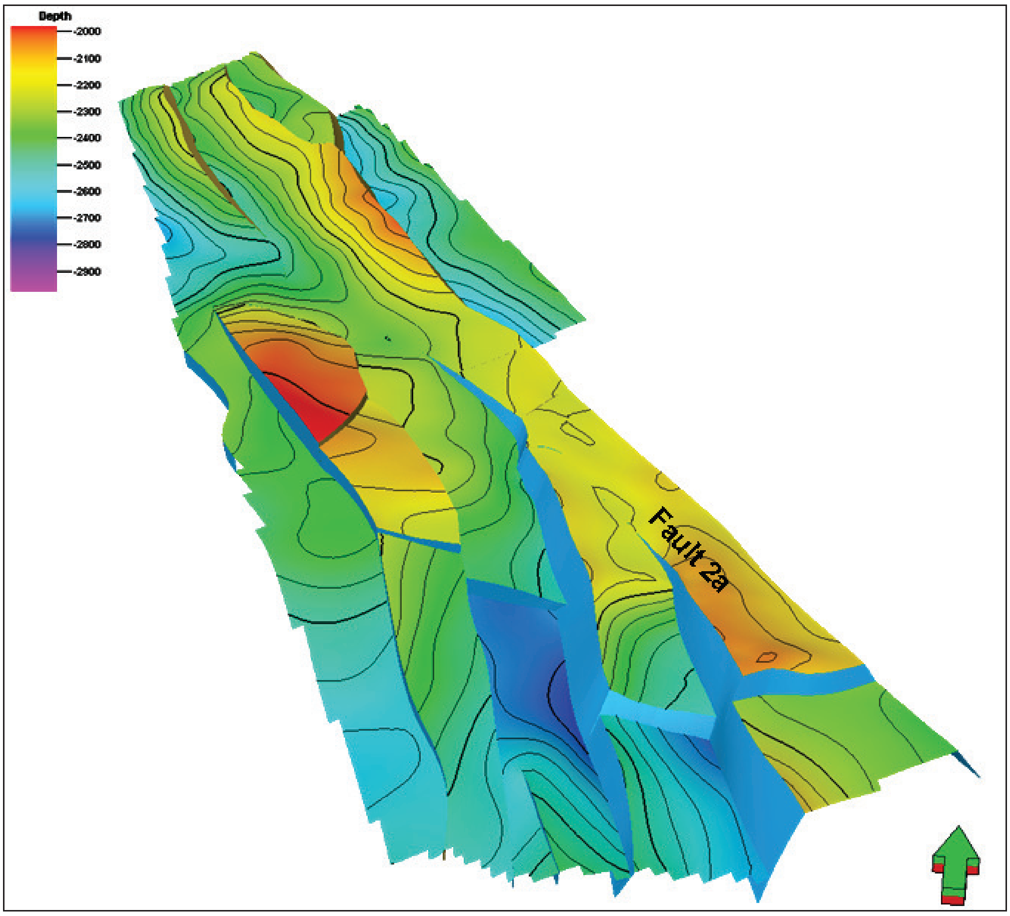

Figure 4-5 **Fault 2a offset in Bergermeer field dies out toward the NW.**
Although below seismic resolution in the North it might still be present throughout the field nonetheless

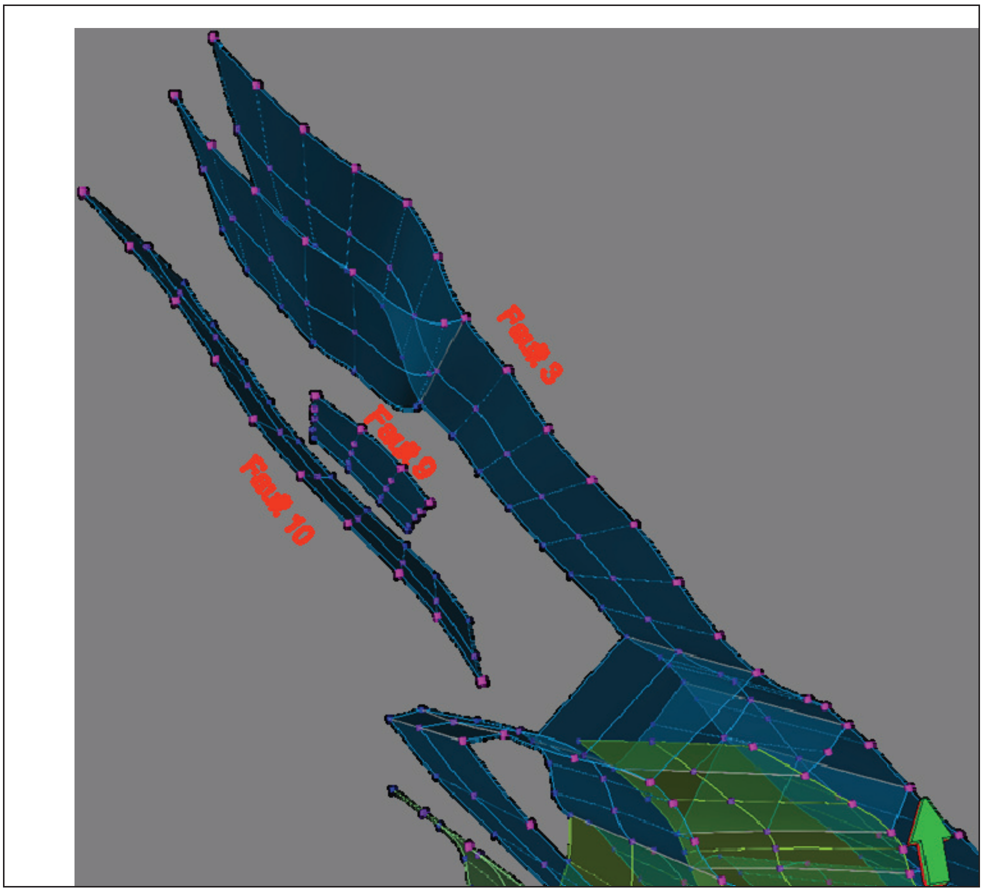

Figure 4-6 Fault 9 (just west of the Groet field) was excluded from the modelling area since it caused gridding problems, and since it was not within any of the fields proper.

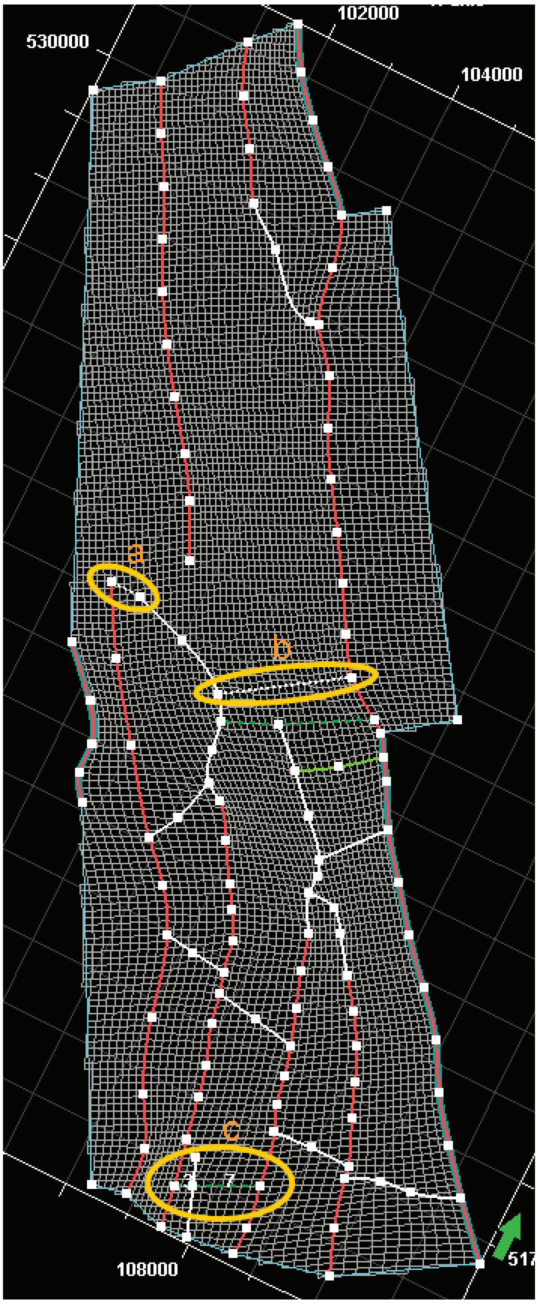

Figure 4-7 **Top view of pillar griding on the modelling area**

Pillar grid determined with boundary polygon (blue) surrounding the modelling area. Fault lines (white) set as a part of a segment boundary and I-trends (green) constrain the X-direction and J-trends (red) constrain the Y-direction of the grid area. The Pillar gridding with lateral grid block dimension of 100*100 meters.

a: Fault 18 (non-active, constraining segmentation)

b: Fault 19 (non-active, constraining segmentation)

c: I-trends determined by seven grid blocks

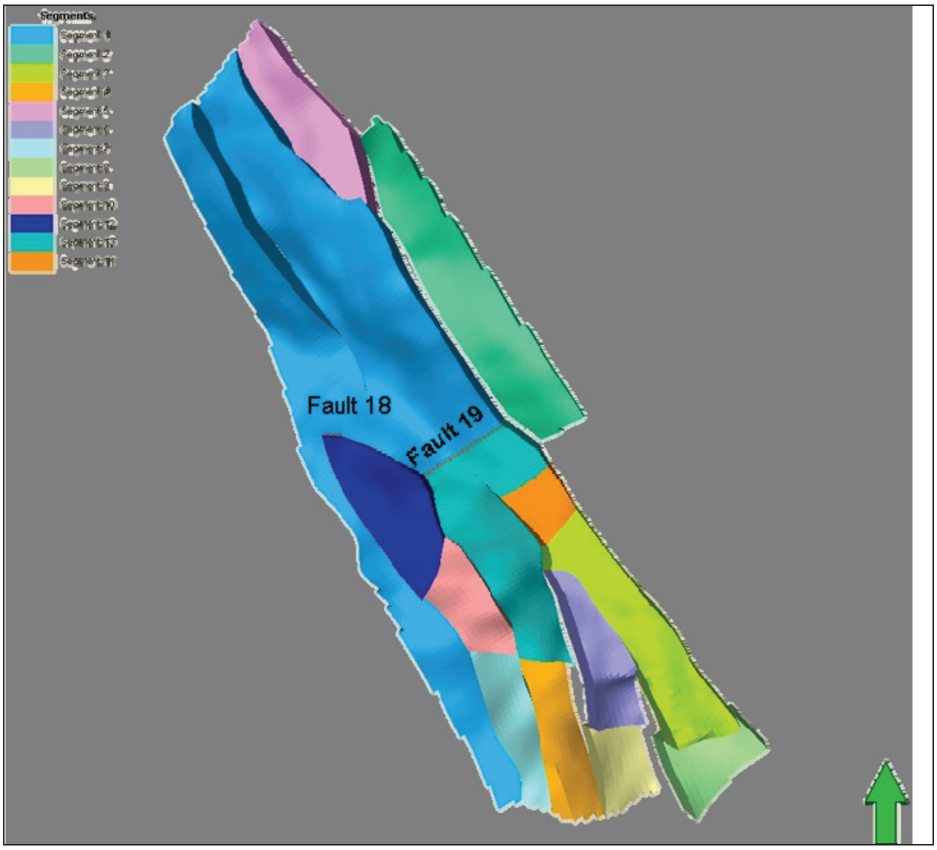

Figure 4-8 **Top view of segmentation in the modelling area**
Synthetic (zero-throw) faults 'fault 18' and 'fault 19' were added to complete this segment separation of the BER and BGM fields from GRT (cf. Figure 4-7).

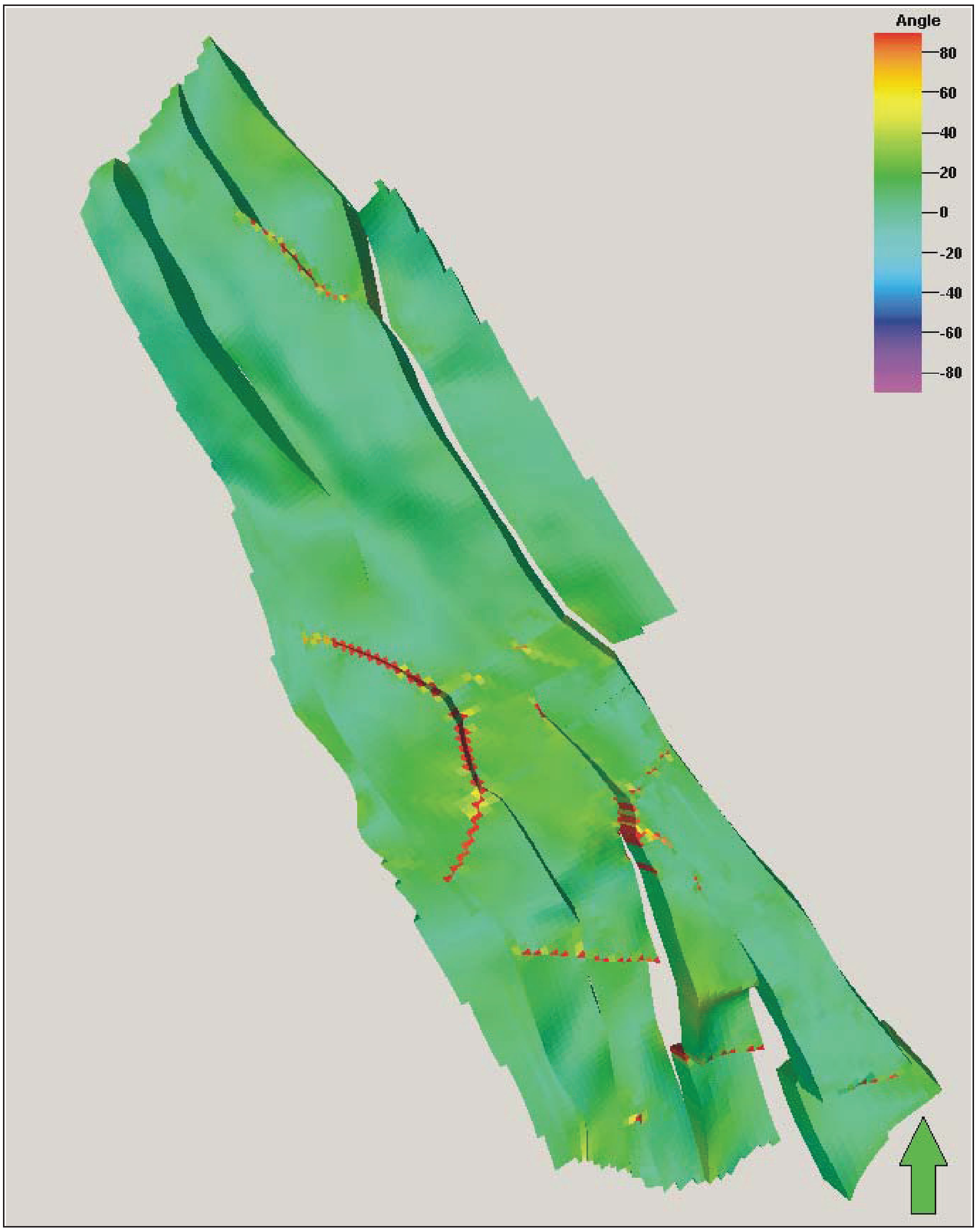

Figure 4-9 **Geometry modelling for grid IJ angle as a QC of pillar gridding**
The areas point to skewed gridblocks at fault planes. Other than these (hardly avoidable) issues, the grid looks quite clean.

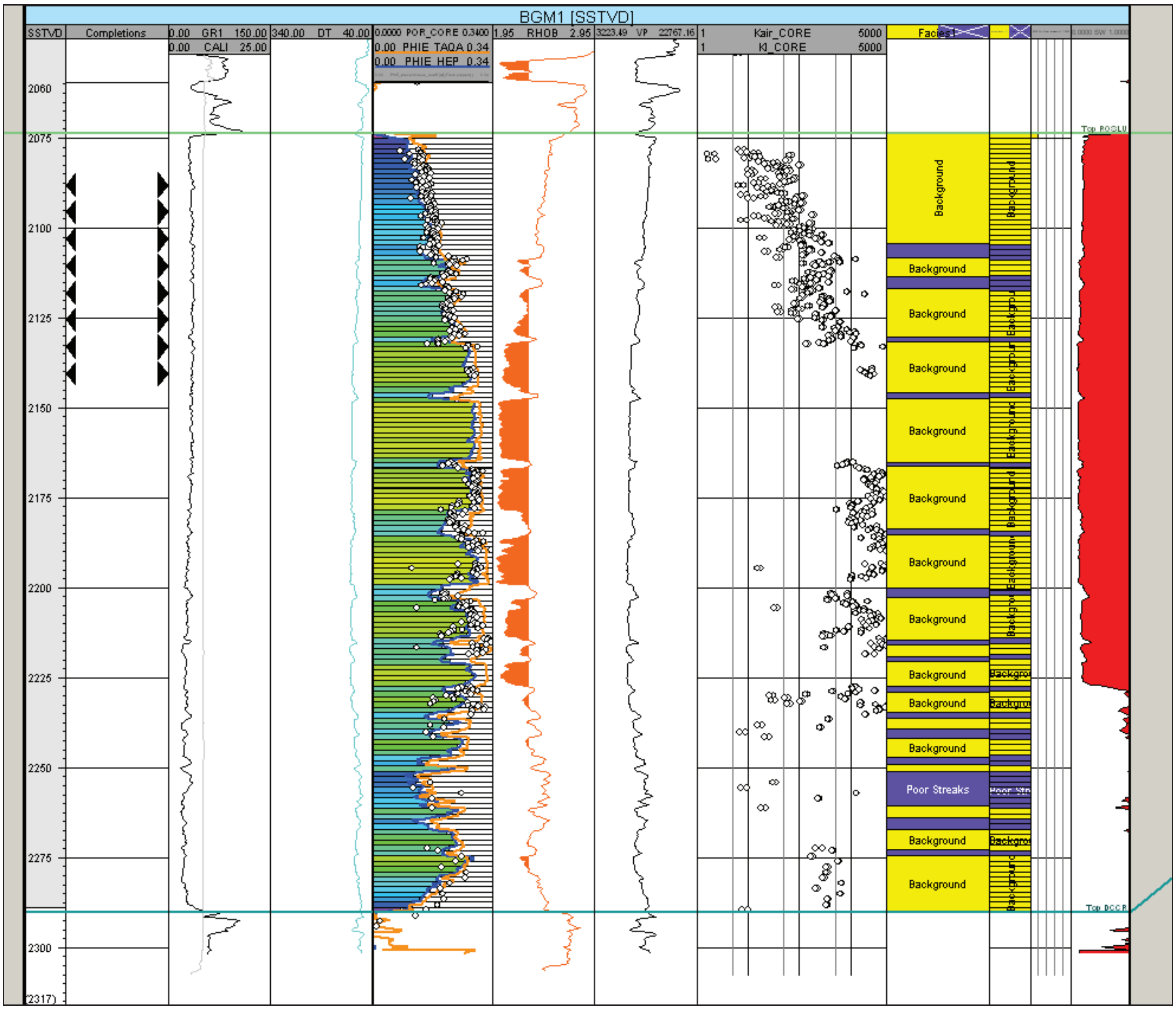

Figure 4-10 Sample facies picks; good porosity (yellow) versus low porosity streaks (purple) This figure also shows the upscaling of the facies and the porosity log. Poor streaks facies are all capture in the upscaling log process. QC of PHIE_HEP log (blue line) as a raw log with upscaled PHIE_HEP log showing good match upscaling techniques.

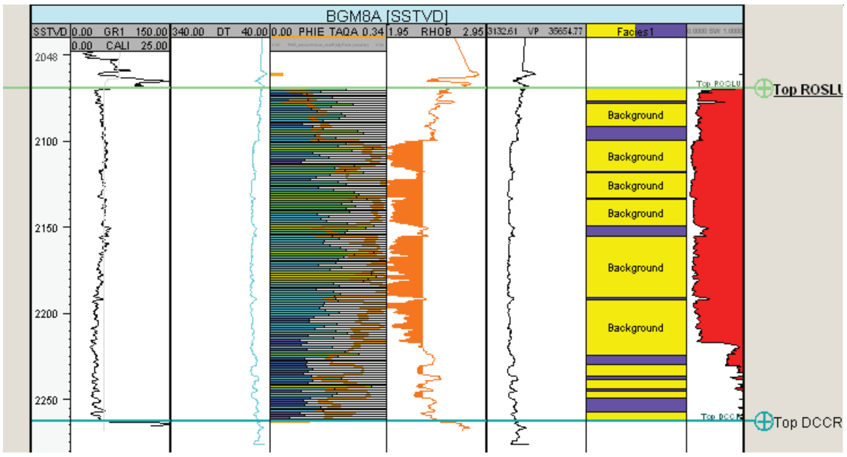

Figure 4-11 Sample facies and porosity picks from QC 3D grid "Isochor_trend100withoutBGM8A".

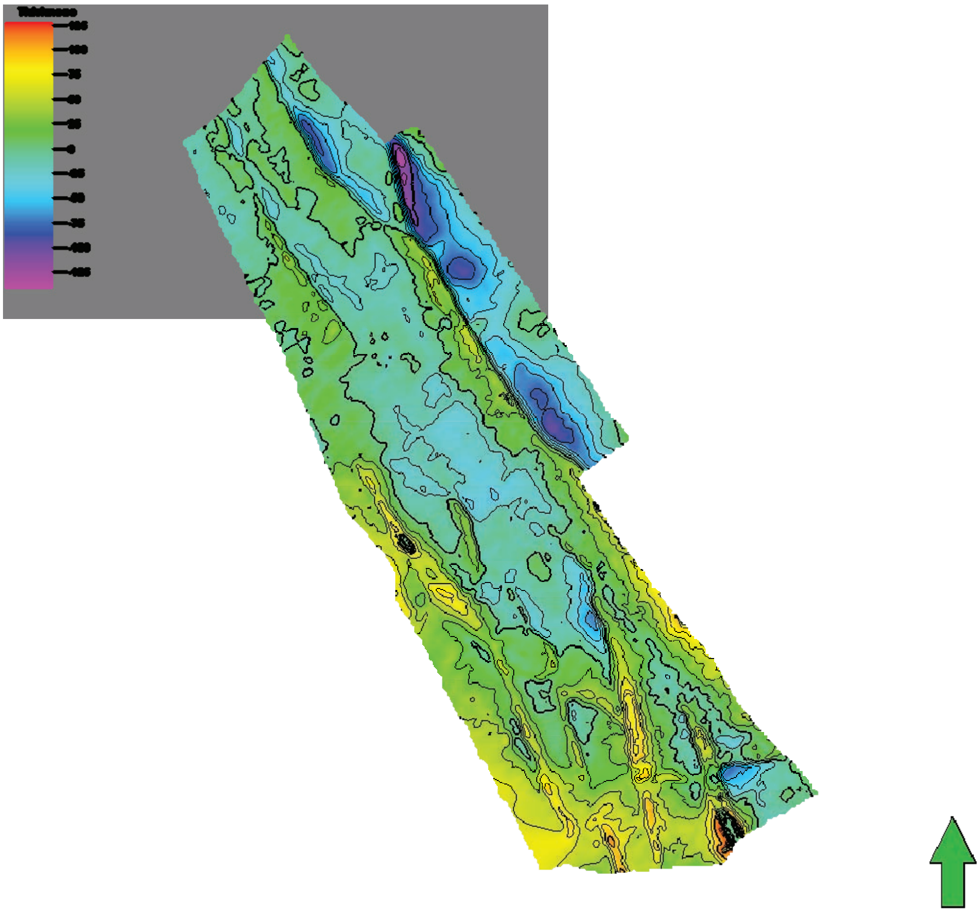

Figure 4-12 Uncertainty map, as provided by Taqa.
Positive and negative values are present. The uncertainty map was used to generate high case and low case 3D grid scenarios based on the absolute value.

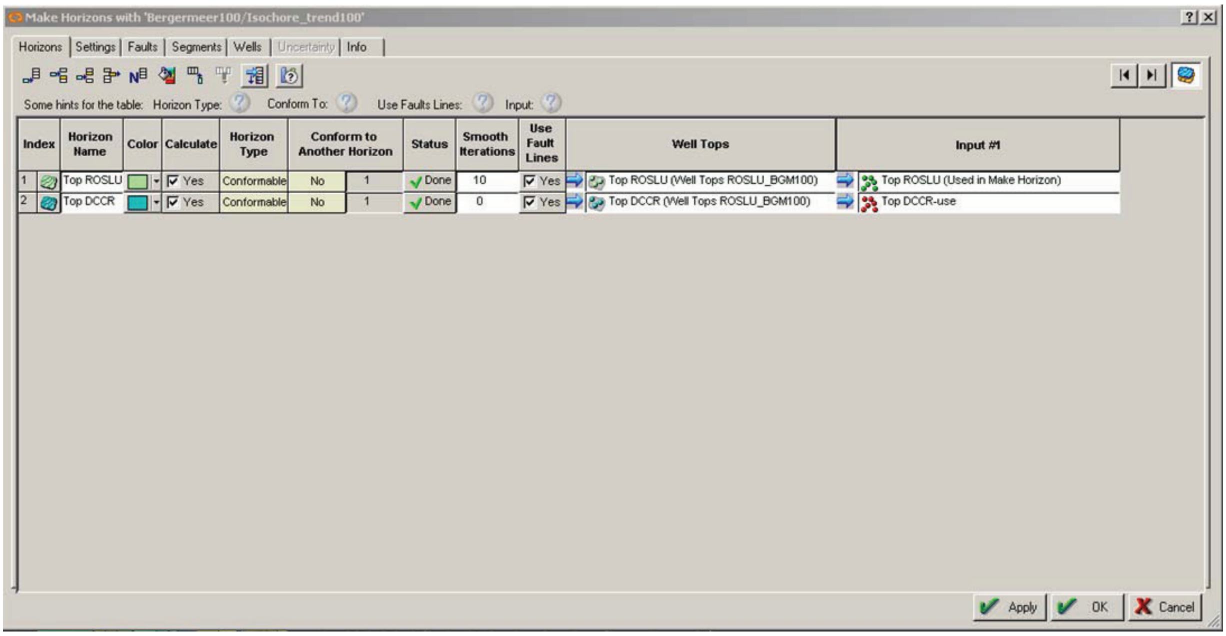

Figure 4-13 **The "Make Horizon" dialog of the Top ROSLU and Top DCCR.**

The horizons were constructed using well tops from the each well, horizon data points as an input data and the fault lines. The top Carboniferous build based on the Rotliegend seismic surface which is isochored down and re-gridded to tie it into the respective well tops, i.e. BGM1 and BGM8A.

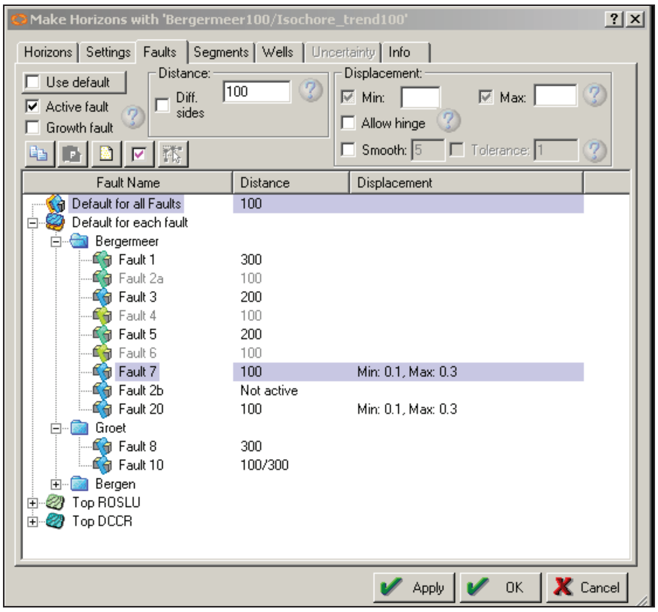

Figure 4-14 **Fault distance in the modelling area**

The general blanking were assigned in order to correct the seismic inaccuracy in proximity of faults.

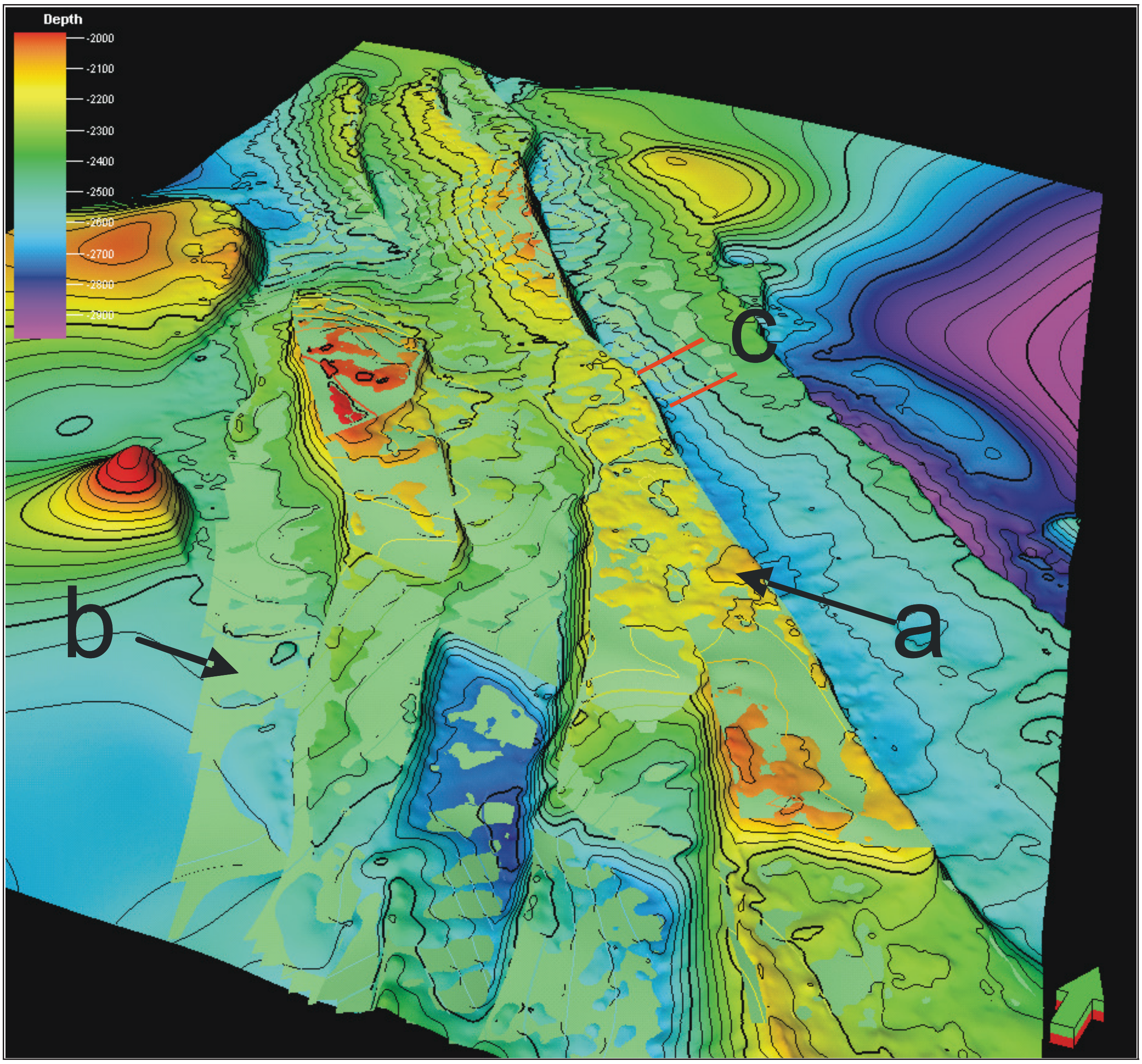

Figure 4-15 **Top ROSLU horizon QC removed surface peaks (bumps) creating from seismic**

a: surface bumps reflected poorly defined seismic interface, mainly happen in reservoir that have contact with Zechstein.

b: QC comparing Top ROSLU horizon (light green) with the Top ROSLU input surface derives from regrided seismic data.

c: Two red lines showing seismic line direction on the modelling area.