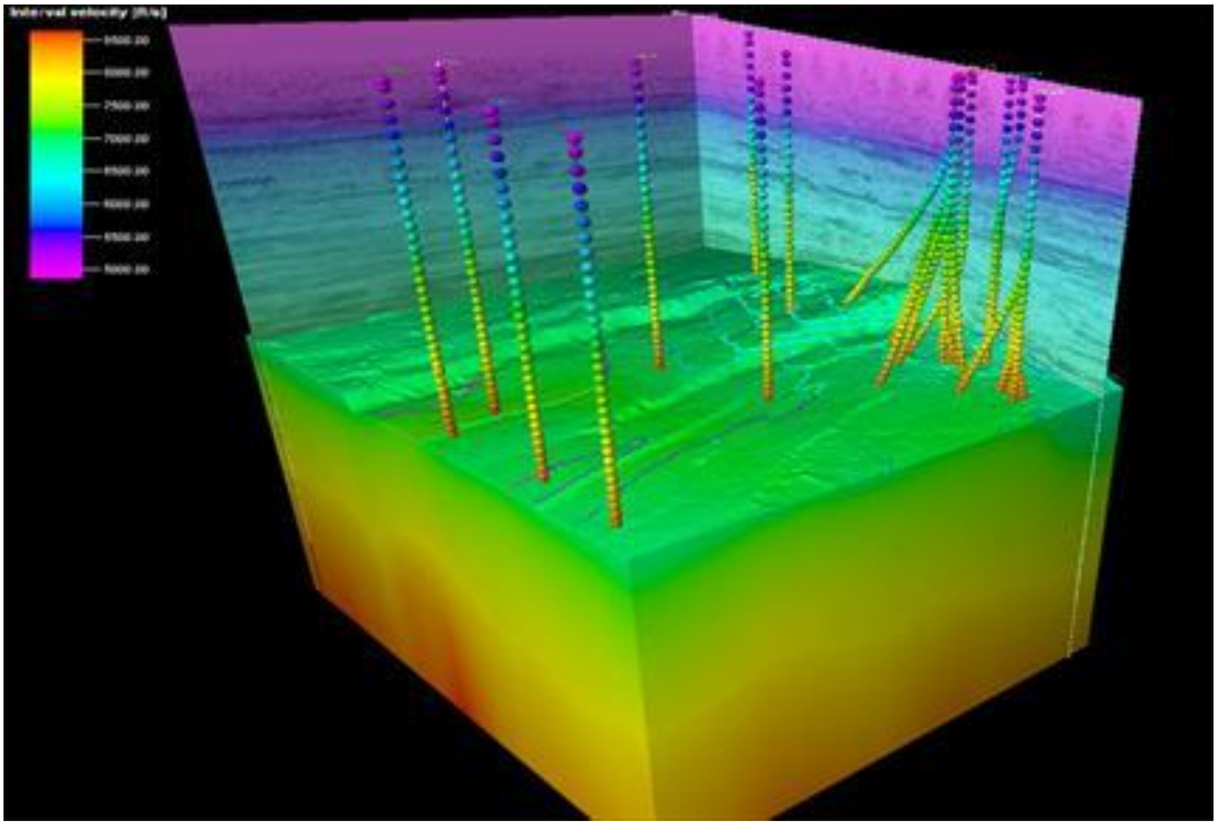
A Time to Depth conversion review of the Dutch North Sea area



3D velocity modelling can be an important contributor to accurate seismic time-to-depth conversion. Seismic velocities (in ft/s, increasing from purple to red-colored) are calibrated with well velocities to obtain this map by using the Petrel Domain Conversion module of Schlumberger.

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Contents

Introduction 3

Time-to-depth conversion 3

Application of T2Dcon: methods and modeling 3

Dutch subsurface well depth errors 5

Aim of study and goals 6

Geological background and setting 6

Setup of analysis 9

Results 11

For Wintershall Noordzee B.V. 11

For ENGIE 21

For NAM 32

Combined analysis 41

General Discussion 46

Conclusions 48

References 49

Appendices 50

1. Bar diagrams of individual wells 50
2. Bar diagrams of T2Dcon errors for individual wells per structural element 73
3. T2Dcon errors for individual wells .... **Error! Bookmark not defined.**
4. List of abbreviations of stratigraphic units 89

Introduction

Time-to-depth conversion

Seismic Time to Depth conversion (T2Dcon) is used in subsurface depth mapping. T2Dcon methods convert processed seismic P-wave Two-Way travel time (TWT) to the depth of a certain target (e.g. reservoir levels), by direct time-depth conversion or developing velocity models (Etris *et al*., 2001).

Seismic data is acquired by transmitting controlled acoustic energy (seismic P-waves) into the Earth. The energy is reflected back from geological boundaries in the subsurface and its TWT is recorded by a multitude of sensors on the earth's surface. Each sensor can detect a single P-wave at a certain time. Combining the detected, reflected energy is called processing and requires multiple steps. Processing produces a synthetic image of the Earth's subsurface. Advanced processing techniques, such as Prestack Depth Migration (PSDM), can be applied to significantly improve seismic imaging (CGG Veritas).

Seismic images display the subsurface as a set of layers. Transitions between these layers are seen as (sometimes bright) reflectors due to an impedance difference. Because of mainly compositional (and stratigraphic) differences between the layers, the layers have different seismic (P-)wave velocities. Once the different layers have been interpreted, T2Dcon can be carried out.

An accurate estimate of reservoir size and depth is key to a successful oil or gas well. This estimate is difficult and the reservoir depth is therefore not always predicted accurately. Mispredictions are often in the range of several 10's-100's of meters (Hoetz, 2012). Many prospects however depend on an accurate assessment of reservoir depths, and also field development and targeting of development wells requires accurate subsurface depth mapping. In many cases the Gross Rock Volume (GRV) appears to be the parameter with the largest uncertainty in estimating static volumes.

Application of T2Dcon: methods and modeling

Direct T2Dcon does not require velocity models and does not take into regard the structure of velocity variations (Etris *et al*., 2001). A time horizon is converted to depth directly by, e.g., applying a fixed translation equation or a spatially-oriented function.

A velocity model can be developed that incorporates different velocities for the different layers. Velocities used in a velocity model are vertical propagation velocities and not the processing velocities (provelocities) used in processing. The development of a reliable velocity model requires considerable attention. A reliable velocity model requires three conditions (Etris *et al*., 2001): (1) it needs to be geologically consistent; to be based on an appropriate layering scheme and account for lithologic contrasts, geological inconsistencies (i.e. folds and faults), and effects of anisotropy within a layer, (2) use appropriately detailed velocities and (3) incorporate all available, best fitting (from seismic and wells) velocity information.

The multi-layer velocity model can be used to incorporate these three characteristics. The different layers are usually composed of one or more stratigraphic units. A velocity function is made for each layer.

There are three different velocity functions (see figure 1), based on either average velocities, interval velocities or instantaneous velocities, depending on how the velocity behaves with depth (Etris *et al*., 2001). Applying either of these, results in the depth of the base of a layer using the previously calculated top of that layer, calculating downward for the entire stratigraphy. The base of each layer is the top of the directly underlying layer.

In using average velocities (fig. 1a), one ignores the layers and simply uses a single velocity for surface to top reservoir. Subsurface detail is ignored and hence predicted depths are usually inaccurate.

In case the velocity pattern with depth lacks consistency or intermediate horizons cannot be easily defined, using average velocities may be plausible.

Constant interval velocities (fig. 1b) are assigned for each layer within a given well, which results in a higher degree of detail.

Because velocities often vary with depth (e.g. because of the effect of compaction, which increases velocities), it may be desirable to use instantaneous velocities (fig. 1c), varying over very small depth increments (within a single layer). The easiest way to include such variations is to model the instantaneous velocity as a linear function of depth: $V(z) = V_0 + kZ$, with $V(z)$ being the instantaneous velocity at depth Z, and V_0 and k are the intercept and slope of the linear function, respectively (Al-Chalabi, 1997).

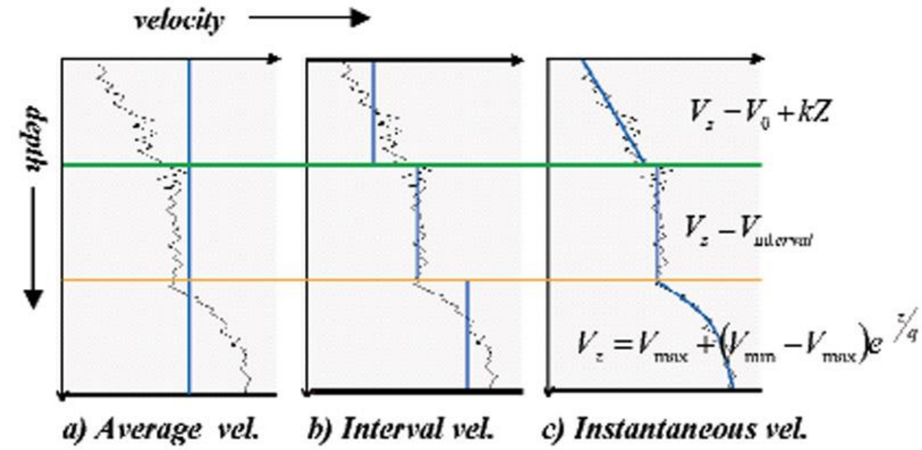

Figure 1 – The different types of velocity descriptions used in the multi-layer velocity model. The green and yellow horizontal lines represent different horizons. After Etris et al. (2001).

A way to assess which velocity vs. depth $[V(z)]$ function is best applicable, is to calculate the depth of a layer that is already known from earlier wells and subsequently compare the results with the $V(z)$ function. Likely, a multitude of $V(z)$ functions will give a good fit. The best fit is obtained by the $V(z)$ function that can also predict depths at locations away from the wells. It will fit the actual $V(z)$ curve over the entire depth range for the given layer and not merely for the top of the layer. The 'discrepancy analysis' (Al-Chalabi, 1997) is a quantitative method to determine the correctness of $V(z)$ function fit. The aim of the discrepancy analysis is to find a combination of V_0 and k that yield the closest fit to the velocity vs. depth data for all wells in an area (and not merely a few wells). This goodness-of-fit (discrepancy, F) can be calculated by the following equation: $F(V_0, k) = [\sum_{i-1}^{m} \frac{(Vi-Ci)^q}{m}]^{\frac{1}{q}}$ (Al-Chalabi, 1997), where Vi and Ci are the i^{th} actual (observed) velocity and the velocity used for the velocity function respectively,

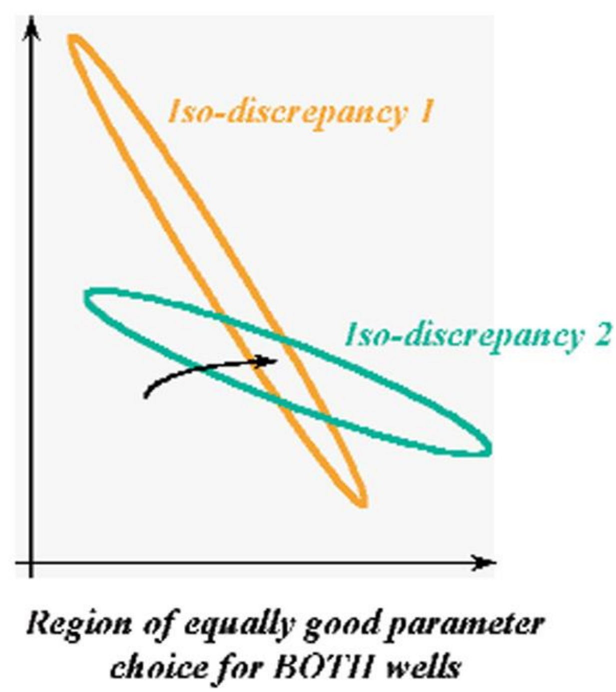

Figure 2 - The crossplot space of V_0 and k. Vo and k are set at the y and x-axis (one for each axis). After Etris et al. (2001).

m is the number of depth points sampled and q is the norm. Typically, a range of V_0 and k parameter pairs is found to meet the discrepancy. In figure 2, discrepancy may be justified for a smaller range of V_0 and k when incorporating a larger amount of wells in the same plot. In this way, it is possible to reduce the best possible pairing of V_0 and k for a combination of wells.

Geostatistics provides techniques to combine and integrate all available velocity data. Combining velocity data is however to be carried out with caution due to the degrees of uncertainty the different types of velocity data bear.

T2Dcon is also carried out by using Prestack Depth Migration (PSDM) velocity models. PSDM allows focusing on depth, instead of only on time in the modeling and interpretation of seismic data and significantly improves the understanding of the subsurface. Especially geological heterogeneities (i.e. salt domes and faults) can be better imaged.

Dutch subsurface well depth errors

Despite the many different possibilities that T2Dcon offers, as said, velocity data intrinsically bear a certain degree of uncertainty and T2Dcon depth errors remain.

Earlier studies (e.g. Hoetz, 2012 and Meyer Viol, 2015) have demonstrated the presence and the extent of depth errors. Meyer Viol (2015) presents a depth error analysis that is performed on 101 exploration wells drilled in the Dutch subsurface in the period 2005-2014 (figure 3). Wells drilled within 0-20m of prognosed target depth are considered to be in an acceptable range.

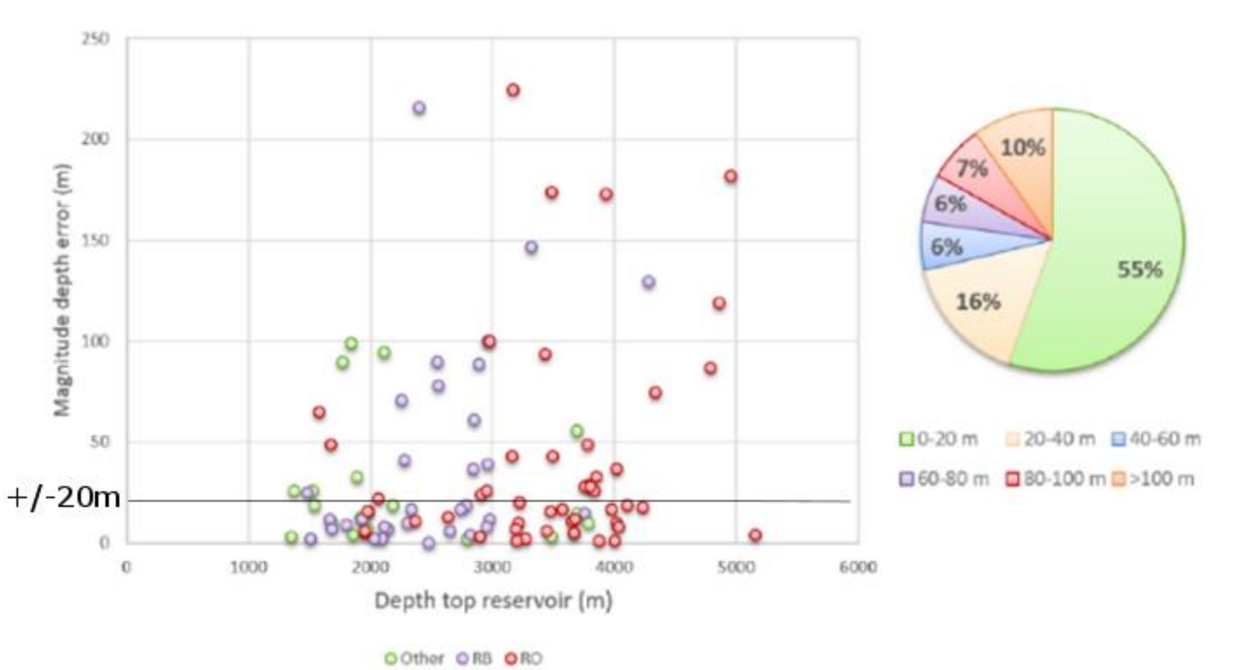

Figure 3 – On the left: Magnitude of depth error (m) vs. Depth of top reservoir (m) for 101 exploration wells drilled between 2005-2014. Colors indicate top of the layer in which the main target lies (RB = Triassic Bunter, RO = Rotliegend). On the right: the % of wells drilled in a certain error range (denoted by colors below). The black, horizontal line labeled '+/-20m' represents the acceptable range of T2Dcon errors at target depth.

Following Meyer Viol (2015), the average magnitude of the depth error for the 101 analyzed wells is 38.1 meters and reservoir depth was on average 1.3% off the predicted target for average reservoir depth of 2915 meters.

Figure 4 indicates the extent of T2Dcon depth errors, based on a different database, incorporating wells with EBN participation in the period 2006-2010.

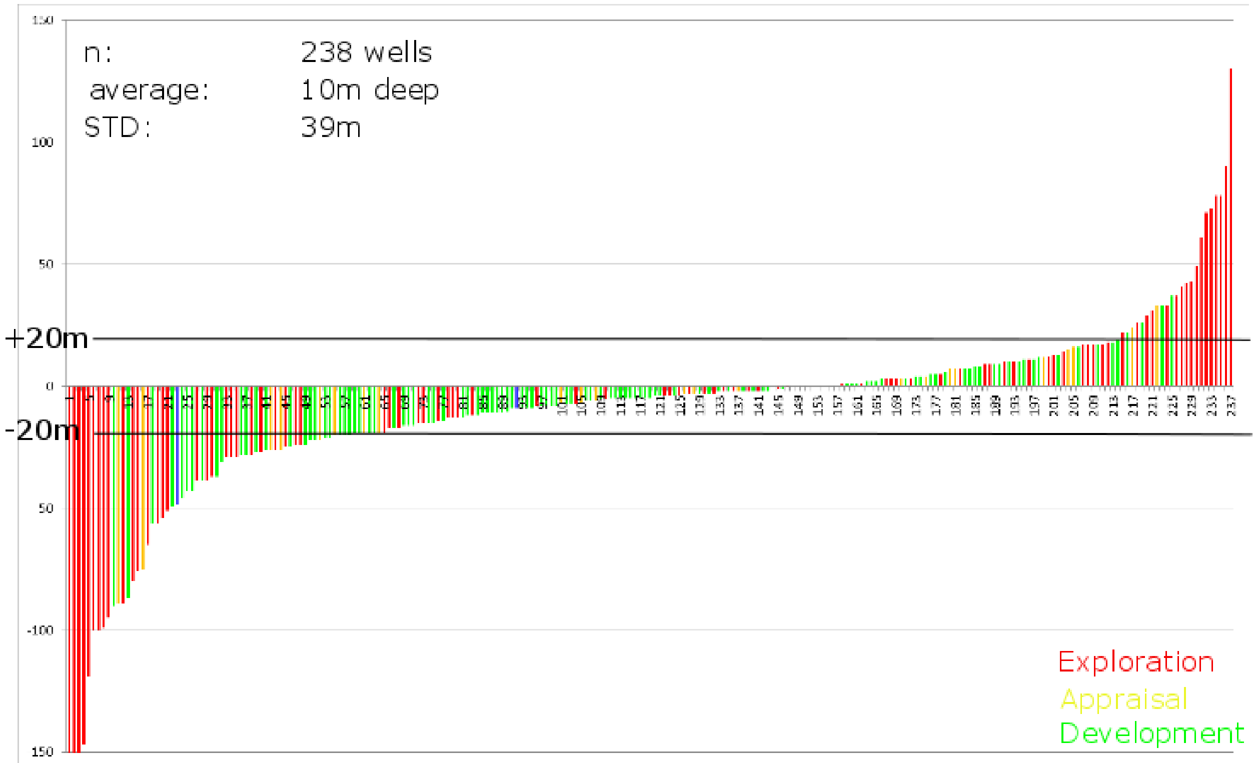

Figure 4 – Depth prediction quality of wells with EBN participation in the period 2006-2010. n: number of wells, average: average T2Dcon error, STD: standard deviation. T2Dcon errors are expressed as depth errors (y-axis: m), deep or shallow to prognosis. The black, horizontal lines labeled '+20m' and '-20m' represent the acceptable ranges of T2Dcon errors at target depth. After Hoetz (2012).

Aim of study and goals

The aim of this study is to investigate which sections of the (offshore and onshore) Dutch North Sea area have greatest difficulties with T2Dcon. For this purpose, a multitude of different wells (differing in age) of the three different operators WIintershall, ENGIE and NAM have been statistically analyzed for the quantity and magnitude of T2Dcon errors. The relationship between subsurface geology and employed T2Dcon methods and T2Dcon errors is tested. Interviews with the operators have been carried out, operator-specific analyses have been presented and the subsequent discussion and feedback have been used to complement the early conclusions of this report. Operator-specific sections are added to this general report and the discussion is based on those. Finally, operator-specific recommendation sections have been implemented in the report and general conclusions will be presented.

At EBN B.V. it is possible to access virtually all E&P welldata in the Netherlands. This offers a unique opportunity to compile a personal database to guide the extraction of learnings and statistics on drilling performance and subsurface parameters associated with T2Dcon. All data used for the analysis is coming from EBN.

Geological background and setting

The Dutch (offshore and onshore) North Sea area can be subdivided in multiple structural elements (fig. 5).

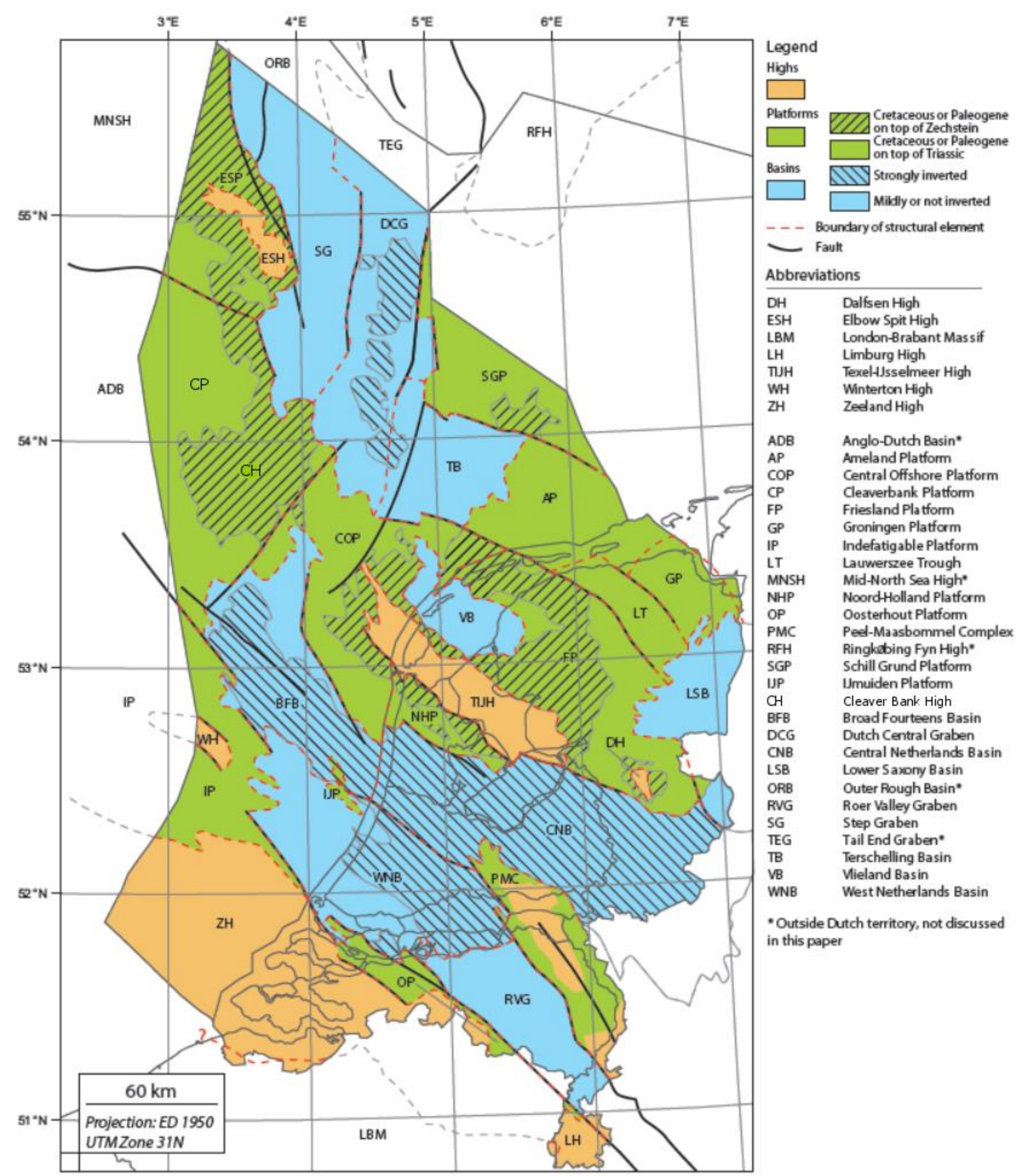

Figure 5 – Modified Late Jurassic - Early Cretaceous structural elements of the Netherlands after Kombrink et al. (2012) which was updated to more clearly define the boundaries between all structural elements and rename the elements in such way that it is clear what tectonic history an element has. This map mainly serves to distinguish between areas that have distinct burial, inversion and erosion histories. Modifications include the addition of the Cleaver Bank High.

In the following description of structural elements that are of importance to this report, the research of Kombrink et al. (2012) and Duin et al. (2006) will be maintained. In the description of their general geological histories, the research of Duin et al. (2006) will be quoted. Both studies use slightly different classification schemes and names for structural elements. The names and classification after Kombrink et al. (2012) will be maintained, with an exception: The Cleaverbank Platform (CP) has been subdivided into two distinct structural elements: the Cleaverbank Platform (CP) and the Cleaver Bank High (CH), fig 5, because maps used in the report maintain this subdivision.

First-order classification of structural elements distinguishes between highs, platforms and basins. A single structural element is defined here as the combination of all regional structures that have a uniform deformation history of faulting, uplift and erosion within a specific time interval (Duin et al., 2006). Often, fault zones/systems exist in between structural elements.

- A high is an area that has experienced significant non-deposition and erosion down till Carboniferous or Permian strata.
- A platform is mainly influenced by Late Jurassic erosion and is characterized by the absence of Lower and Upper Jurassic strata.
- A fault-bounded basin in which generally Jurassic sediments have been preserved is termed a graben.

The Variscan orogeny (Late Carboniferous – Permian; fig. 5) resulted in faulting in basement rocks. the Cleaver Bank High (CBH), Groningen High (Groningen Platform, GP) and Lauwerszee trough (LT) came into existence through wrench tectonics (Duin et al., 2006; Mijnlieff, 2005) and faults that developed have been reactivated later (Duin et al., 2006 and references therein). The Central Netherlands Basin (CNB) developed by extensional tectonics in the Permian. The Dutch Central Graben (DCG) and Terschelling Basin have developed salt diapirs and walls in the Zechstein.

Extensional tectonics initiated in the Permian for the CNB, and in the Late Jurassic – Early Cretaceous for most other structural elements, and was ongoing till Late Kimmerian (150-140 Ma). The Broad-Fourteens basin (BFB) came into existence during the Triassic. Salt was displaced in the northern offshore and northeastern onshore from the Triassic onwards.

Late Jurassic – Early Cretaceous tectonics played a large part in the structural configuration of the Dutch subsurface.

The Late Jurassic – Early Cretaceous is a structurally very complex period due to basin subsidence and uplift of flanking platforms, which was associated with salt movement (Duin et al., 2006). The uplifted flanking platforms were eroded and sediment accumulated in the relatively small, local basins located along the edges of the uplifted blocks.

During the Late Jurassic – Early Cretaceous the BFB was probably linked with the Dutch Central Graben (DCG). The DCG was exposed to extensional faulting during the Late Cretaceous, but it may have existed as a structural low earlier (since the Carboniferous). Both the BFB and DCG were inverted during the Late Cretaceous and Paleogene.

The West Netherlands basin (WNB) came into existence in the Jurassic and was mildly to strongly inverted in the Late Cretaceous and Paleogene.

The Terschelling Basin (TB) developed in Latest Jurassic times. Both its northern and southern boundary faults were reactivated from reverse to normal. The basin has only been mildly inverted.

The Vlieland Basin (VB) was probably connected to the TB and acted as a Late Jurassic and Early Cretaceous depocenter. Buoyancy forces associated with the Zuidwal volcano activity lead to the Upper Jurassic-Lower Cretaceous succession having reduced thickness, compared to other rift basins (De Jager, 2007).

The Lower Saxony Basin (LSB) developed in the Jurassic through extension. It was strongly inverted during the Late Cretaceous.

The Ameland Platform (AP), Friesland Platform (FP), Central Offshore Platform (COP), Inde(fatigable) Platform (IP) and Schill Grund Platform (SGP) originated in the Jurassic and were subsequently inverted in the Cretaceous.

The Cleaver Bank High (CP; after Kombrink et al., 2012), was probably a stable block during the Early Cretaceous, with Jurassic, Triassic and Permain (Zechstein) sediments being eroded.

Setup of analysis

The initial task of this assignment was to make a statistical analysis of T2Dcon errors in the Dutch North Sea area. For that purpose, a quick general survey of T2Dcon errors of wells in the Dutch North Sea area was carried out, from which a statistically interesting database was constructed including a multitude of wells from the three main operators drilling in the Dutch North Sea (offshore and onshore) area: Nederlandse Aardolie Maatschappij (NAM), Wintershall and ENGIE.

Microsoft Excel® 2013 and TIBCO Spotfire® have been combined for analysis purposes. Spotfire is analytics software that is used for data research. It has been chosen for analysis because it offers a quick and easy manner to incorporate multiple databases and plot data from the databases in a variety of diagrams, combined in a single file. The data analyzed (the location of wells) in Spotfire may be linked to the Geographic Information System (GIS), additionally incorporating layers displaying different information (i.e. the location of basins or country borders). 'TDCON act vs prog 2015.xlsx' (from which figure 4 originates; author: Pieter Slabbekoorn) is the database file for general Spotfire analysis which is used to relate a number of different parameters and plot wells on overview maps. It includes 238 wells for different operators.

Excel has been used to carry out a well-specific analysis for the eventual database of wells for the three operators. 'PDDCAT_template.xlsx' (author: Guido Hoetz) serves as template for the prognosed and actual well-top input depths. This template is used to create a number of different bar-diagrams which relate a number of different parameters, which will be presented in this report. The bar-diagrams mainly relate different T2Dcon errors with well-tops of individual wells and the combination of wells (for the three operators separately). Figure 6 shows the 'PDDCAT_template.xlsx' with the calculations of the different parameters.

PROGNOSIS: data for graph											
tops		prognosis			actual						
original	renamed	depth	Range shallow	Range deep	depth	Dz(Prog - Act)	dDz	Dz/depth_act	dDz/depth_act	Deviation/depth_act	
	for graph	m	m	m	m	m	m				
	surface	0	#N/A	#N/A	0						
Top Middle NS Group			0	0							
Top Lower NS Group			0	0							
Top Chalk	CKGR	1602	16	-16	1628	-26	-26	-0,015970516	-0,015970516	0,00984	
Top Rijnland	KNGLU	2253	23	-23	2280	-27	-1	-0,011842105	-0,000438596	0,009882	
Top Niedersaksen			0	0							
Top Scruff	SGKIS	2444	24	-24	2476	-32	-5	-0,012924071	-0,002019386	0,009871	
Top Schieland			0	0							
Top Altena	ATAL	2530	25	-25	2555	-25	7	-0,009784736	0,002739726	0,009902	
Top UGT	RNKPU	2683	27	-27	2644	39	64	0,014750378	0,024205749	0,010148	
Top LGT			0	0							
Top ZE	ZE	2711	27	-27	2700	11	-28	0,004074074	-0,01037037	0,010041	
Top Upper Rotliegend	ROCL	3588	36	-36	3540	48	37	0,013559322	0,010451977	0,010136	
Top Limburg	DCHP	4110	41	-41	4120	-10	-58	-0,002427184	-0,01407767	0,009976	

Figure 6 - Excel 'PDDCAT_template.xlsx' input document for fictional well input data.

(red) $$\mathrm{Dz} = \mathrm{D}_{prog} - D_{act}$$

(green) $\mathrm{dDz} = \mathrm{D}_{act2} - D_{act1}$

(blue) $\frac{\mathrm{Dz}}{\mathrm{z\_act}}$

(yellow) $\frac{\mathrm{dDz}}{\mathrm{z\_act}}$

(purple) $\frac{\mathrm{range\ shallow}}{\mathrm{z\_act}}$

Dz and dDz are T2Dcon errors (actual – prognosed depth of well tops). dDz is used to correct for additional depth T2Dcon errors of a shallower formation tops (difference between actual – prognosed depth of well tops for two consecutive well top depths).
Both expressions $\frac{\mathrm{Dz}}{\mathrm{z\_act}}$ and $\frac{\mathrm{dDz}}{\mathrm{z\_act}}$ relate T2Dcon errors to actual formation top depth (Dz divided by actual depth of the corresponding well top and dDz divided by actual depth of corresponding well top, respectively). $\frac{\mathrm{range\ shallow}}{\mathrm{z\_act}}$ is the corresponding deviation (1% of prognosed depth of well top divided by its corresponding actual depth). All errors are for the tops of the stratigraphic groups in the left column of the 'PDDCAT_template.xlsx' template and thus indicate T2Dcon errors for the overlying stratigraphy.

For analysis the Middle North Sea Group (NM) and the Lower North Sea Group (NL) are combined as North Sea Supergroup (N) and the Niedersaksen Group (SK), Scruff Group (SG) and the Altena Group (AT) are combined as Jurassic, expressions which are statistically more meaningful. Excel bar diagrams that have consistently positive values are based on absolute T2Dcon errors. Seismic marker mispicks have been corrected for by picking the well tops that yield the smallest T2Dcon error.
First-order Excel analysis groups the wells in 4 different units: the main basins (Main Basin), minor basins (Minor Basin), platforms (Platform) and highs (Minor High).
Subsequent analysis groups the structural elements on the basis of similarities in geological history.
For Wintershall, the Broad Fourteens Basin and West Netherlands Basin have been grouped as Main Basin and the Vlieland Basin and Terschelling Basin have been grouped as Minor Basin, with the other structural elements left unchanged.
For ENGIE, the structural elements have been grouped as follows: Platform (Cleaverbank Platform and Central Offshore Platform), Minor High (Cleaver Bank High), Minor Basin (Vlieland Basin), Main Basin (Broad Fourteens Basin and West Netherlands Basin) and Dutch Central Graben (DCG).
For NAM, the following groups are used: Minor Low (Ameland Platform, Lauwerszee Trough and Groningen Platform), Platform (Central Offshore Platform, Friesland Platform and Inde Platform), Main Basin (Broad Fourteens Basin and West Netherlands Basin), Minor Basin (Vlieland Basin) and the combination DCG+CNB+LSB (Dutch Central Graben [DCG], Central Netherlands basin [CNB] and Lower Saxony Basin [LSB]). Existing groups of joined structural elements have not been modified, but new groups are created.
This subdivision per operator will also be maintained in presenting T2Dcon errors for individual wells for the grouped structural elements.

Documentation at EBN has been investigated to look for causes of the T2Dcon errors. These causes have been assembled separately for the operators, as well as in a general way.

The operator-specific analyses, including the summary of causes for T2Dcon errors have been presented to the operators Wintershall and ENGIE, separately (NAM did not cooperate). Subsequent discussion and feedback have been incorporated in the operator-specific reports. The operator-specific reports have been added to the general report. These may have been slightly modified, based on the wishes of the operators.

Main T2Dcon error-related conclusions are made for the operators individually and the results for the different operators are subsequently assembled to have a general discussion and present general conclusions.

For all three operators, confidential information of recently drilled wells has been used for analysis. In order to keep the information confidential, measures have been taken. The names and locations of, and figures associated with confidential wells have been modified.

Results

For Wintershall Noordzee B.V.

For Wintershall Noordzee B.V., 28 wells have been selected for Spotfire and 28 wells (only partly identical to the wells for Spotfire) have been selected for Excel analysis. The analysis has been presented to Wintershall B.V. (attendees: two Area Team Managers, an Exploration Consultant and a Consultant Geophysicist).

Geological Setting and location of the analyzed wells

Figure 7 show the location of the wells analyzed with Spotfire and Excel. Individual analyses of wells by Excel are summarized in appendix in alphabetical order. Tables 1-4 (appendix 3) contain the corresponding T2Dcon error values per well.

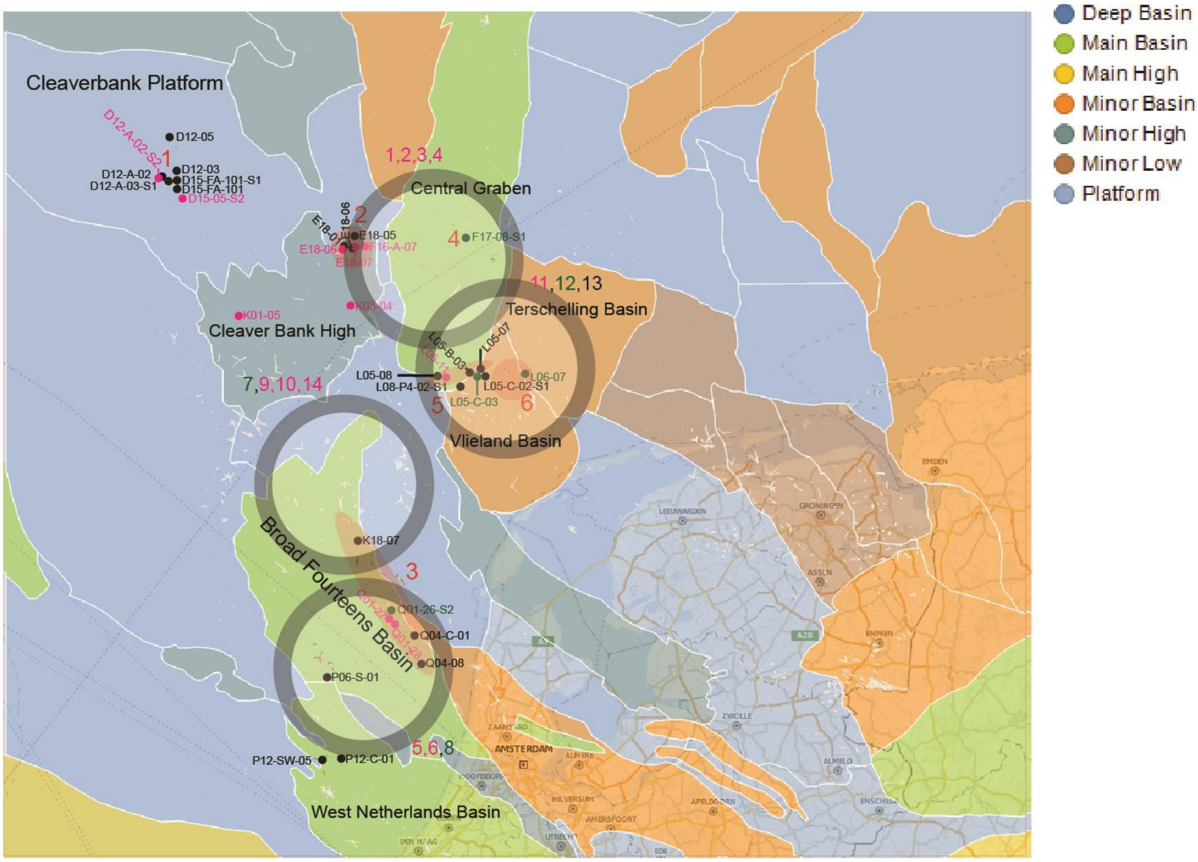

Figure 7 - The location of the wells analyzed with Spotfire (in pink), Excel (in black), and with both Spotfire and Excel (in green). The wells used in the analysis have been labeled with their corresponding well name; these amount to 28. Confidential wells have been labeled with a single digit and assigned an approximate location, the range of which is indicated with opaque, black-rimmed circles. Analyzed wells are certainly located in the Broad Fourteens Basin, Dutch Central Graben (both Main Basin), Vlieland Basin, Terschelling Basin (both Minor Basin), Cleaverbank Platform and Inde Platform (both Platform) and Cleaver Bank High (Minor High). Red, numbered, opaque ellipses and circles and solid dots indicate areas (or specific wells) that have largest T2Dcon difficulties. See the 'General Discussion' (pp. 47-48) for an explanation.

Spotfire analysis

Exploration wells yield the largest average Dz (fig. 8).

Primary targets RBM (Main Buntsandstein Subgroup), ROSL (Slochteren Formation) (and RBMD; Detfurth Formation) yield the largest errors. Primary target CKGR (Ommelanden Formation) yields the smallest errors (fig. 9). This is partly related to the small target depth (fig. 8).

From Spotfire analysis it is apparent that Q01-26-S2, Q01-27, 6, 7, L06-07, 12 and F17-08-S1, yield the largest Dz for vs. z_act_target (fig. 10). These wells are located within the Main Basin and Minor Basin (fig. 7).

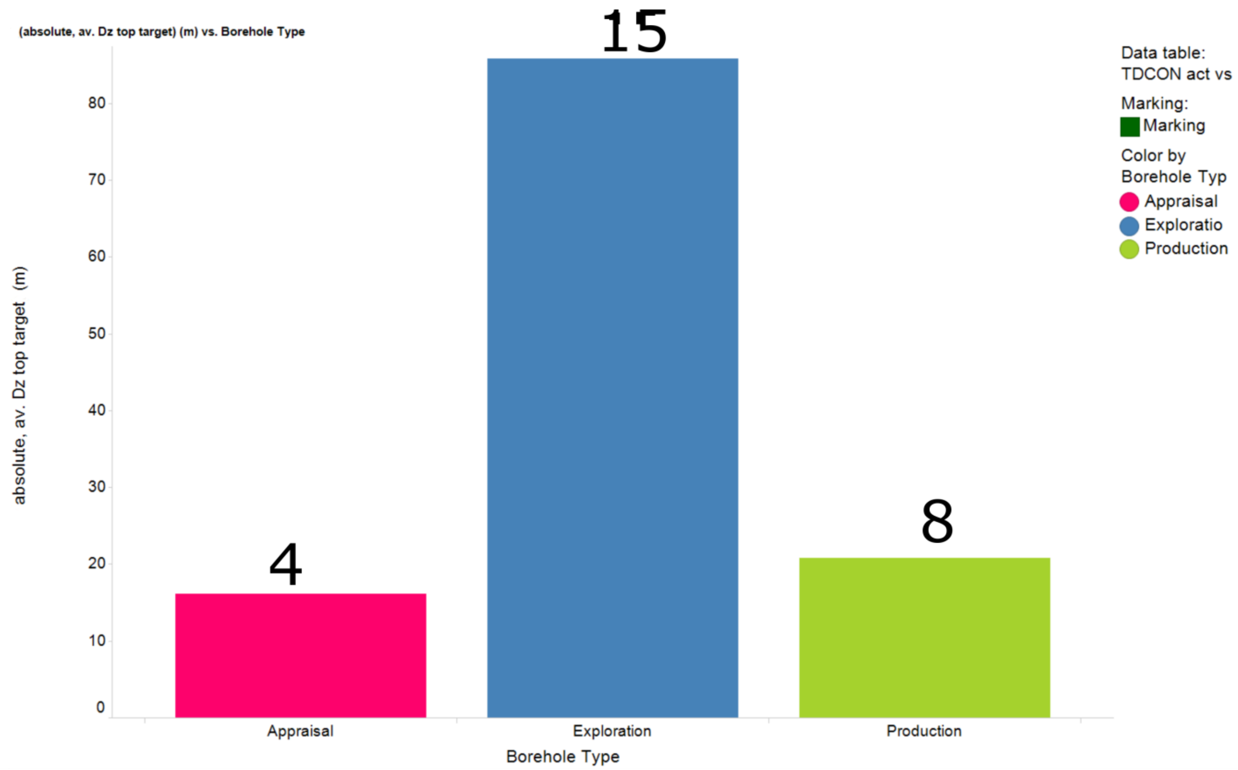

Figure 8 – Average, absolute Dz vs. Borehole Type. Analysis input is derived from 'TDCON act vs prog 2015.xlsm'. Numbers above bars represent well type count.

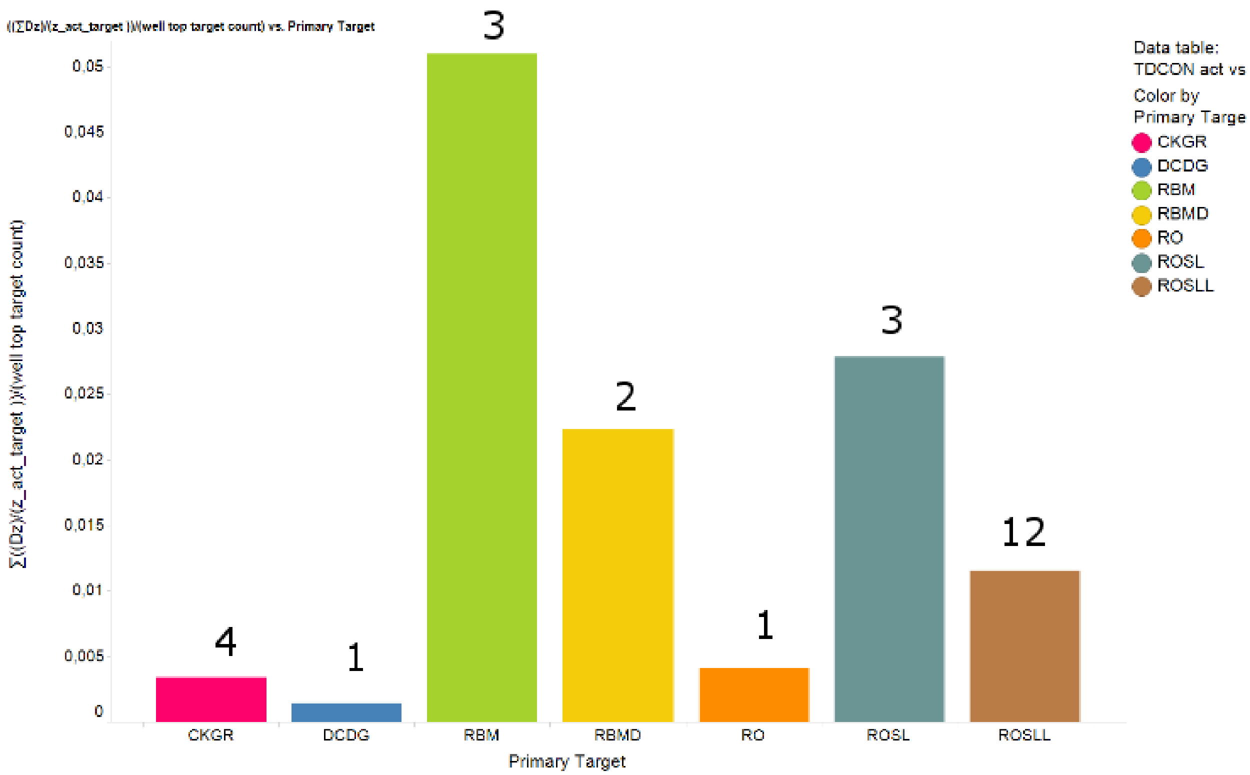

Figure 9 - Absolute $\frac{\sum(\frac{Dz}{z\_act\_target})}{well\ top\ target\ count}$ *vs. Primary Target bar chart. The division of T2Dcon error* Dz *by actual depth per well is calculated for all primary targets and subsequently divided by the count of well top targets. The legend provides well Primary Target. Numbers above bars represent Primary Target count. Analysis input is derived from 'TDCON act vs prog 2015.xlsm'. CKGR = Ommelanden Formation, DCDG = Hospital Ground Formation, RBM = Main Buntsandstein Subgroup, RBMD = Detfurth Formation, RO = Upper Rotliegend Group, ROSL = Slochteren Formation, ROSLL = Lower Slochteren member. See the report text for a discussion of the diagram.*

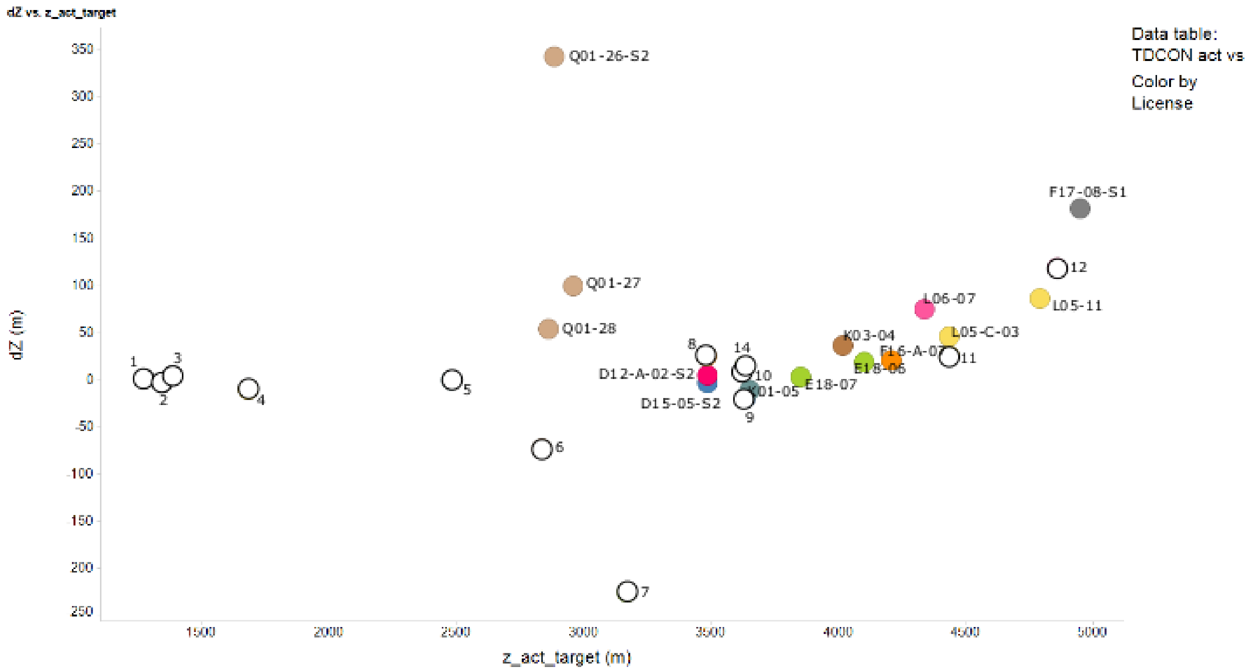

Figure 10 – Dz vs. z_act_target (target depth) scatter plot for 28 labeled Wintershall wells. Colors indicate different well licenses. Confidential wells have been labeled with a single digit (as in fig. 7). The diagram considers additional T2Dcon errors due to increasing target depth (e.g.: a well with Top target delta ~0 at considerable depth has been excellently T2D converted). Analysis input is derived from 'TDCON act vs prog 2015.xlsm'. See the report text for a discussion of the diagram.

Excel analysis

Fig. 11 and 12 show the average, relative Dz vs. well top and average, relative dDz vs. well top, respectively. The bars are calculated by using the formulas $\frac{\sum \frac{\mathrm{Dz}}{\mathrm{z\_act}}}{\text{well top count}}$ and $\frac{\sum \frac{\mathrm{dDz}}{\mathrm{z\_act}}}{\text{well count}}$ for fig. 11 and 12, respectively.

Figure 11 illustrates that wells in the Main and Minor Basin yield overall larger T2Dcon errors than in the Minor High and Platform. Top KN (Rijnland Group) and LGT (Lower Germanic Trias Group) yield large T2Dcon errors in general (in particular for the Main Basin). Whereas top DC (Limburg Group) is the deepest well top, T2Dcon errors are relatively low, compared to other well tops. The exception to this is top DC for the Main Basin.

In correcting for additional prognosed depth, generally T2Dcon errors are equal or slightly lower (note y-axis scale difference), except for the top Jurassic in the Main Basin and top UGT (Upper Germanic Trias) and RO (Rotliegend) in the Minor Basin.

In fig. 12, from top KN downward, T2Dcon errors roughly decrease for the Main Basin. From top ZE (Zechstein Group) downward T2Dcon errors decrease for Minor Basin.

From both figures, it is apparent that increasingly large T2Dcon errors for deep stratigraphic levels of the Main Basin and increasingly lower errors for deep stratigraphic levels for Platform and Minor High are not necessarily related to a difference in depth between the well tops in the different structural elements. DC namely has large T2Dcon errors for the Main Basin even after division by the depth of top DC.

The diagram is not absolutely reliable because some well tops are based on confident seismic markers for which no need exists to depth-correct (personal communication Wintershall). Modification would require thorough investigation of seismic profiles to see which well tops are based on seismic markers and which are not.

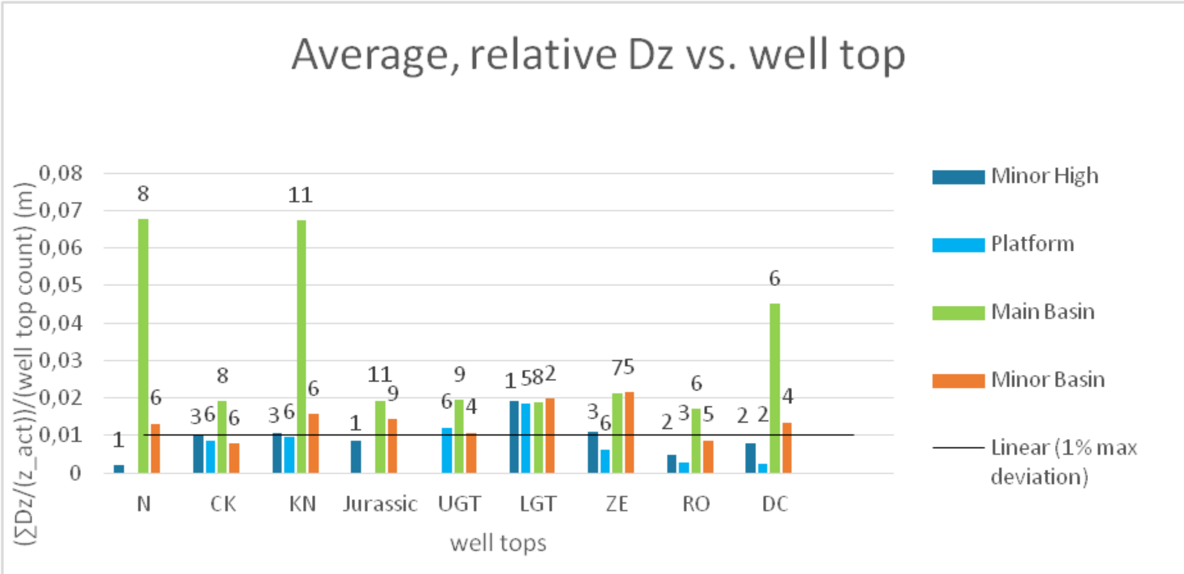

Figure 11 – Average, relative Dz vs. well top for the structural elements related to fig. 7. Bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units.

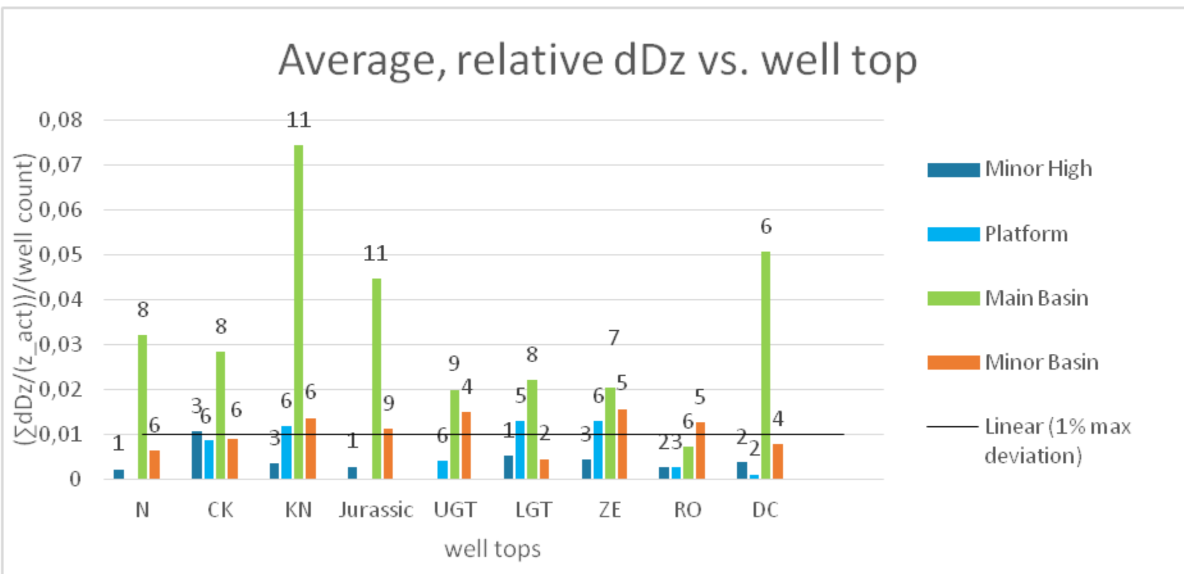

Figure 12 - Average, relative dDz vs. well top for the structural elements related to fig. 8. Bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. Note scale difference from fig. 11. See appendix 4 for a list of abbreviations of the stratigraphic units.

The following analysis is based on a more detailed subdivision of the combined structural elements: Platform (Cleaverbank Platform), Minor High (Cleaver Bank High), Minor Basin (Terschelling Basin and Vlieland Basin), Main Basin (Broad Fourteens Basin and West Netherlands Basin) and Dutch Central Graben (DCG). Discussion of features will be restricted to the Main Basin and DCG structural elements. It must be noted that analysis of DCG is generally based on a small database and increasingly meaningful results could be obtained by enlarging this database.

In separating the DCG from the Broad Fourteens Basin and West Netherlands Basin (here, the combination is termed Main Basin), different results are obtained.

From figures 13 and 14 it appears that the Main Basin brings about more difficulties in the T2Dcon compared to the DCG. From the figures it is evident that top Jurassic and UGT have larger T2Dcon errors for the Main Basin than for the DCG. Especially, top KN and top DC yield larger T2Dcon errors for the Main Basin than for the DCG. This is probably due to severe inversion having occurred in the Main Basin.

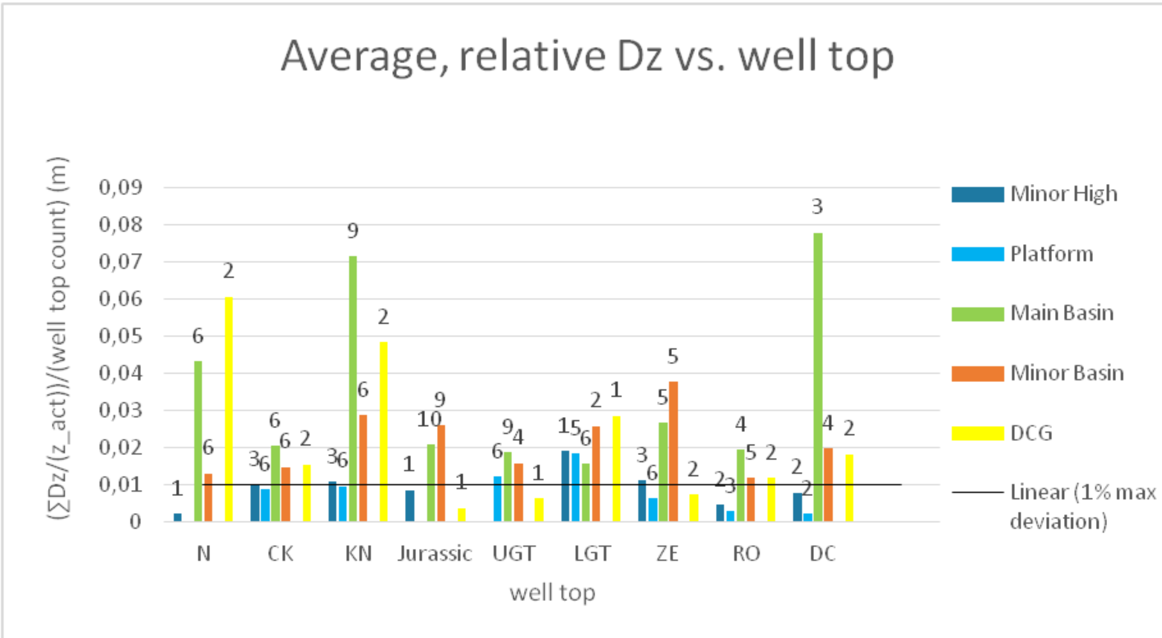

Figure 13 - Average, relative Dz vs. well tops for the structural elements Platform (Cleaverbank Platform), Minor High (Cleaver Bank High), Minor Basin (Terschelling Basin and Vlieland Basin), Main Basin (Broad Fourteens Basin and West Netherlands Basin) and Dutch Central Graben (DCG), after similarities in structural characteristics and geological history. Bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units.

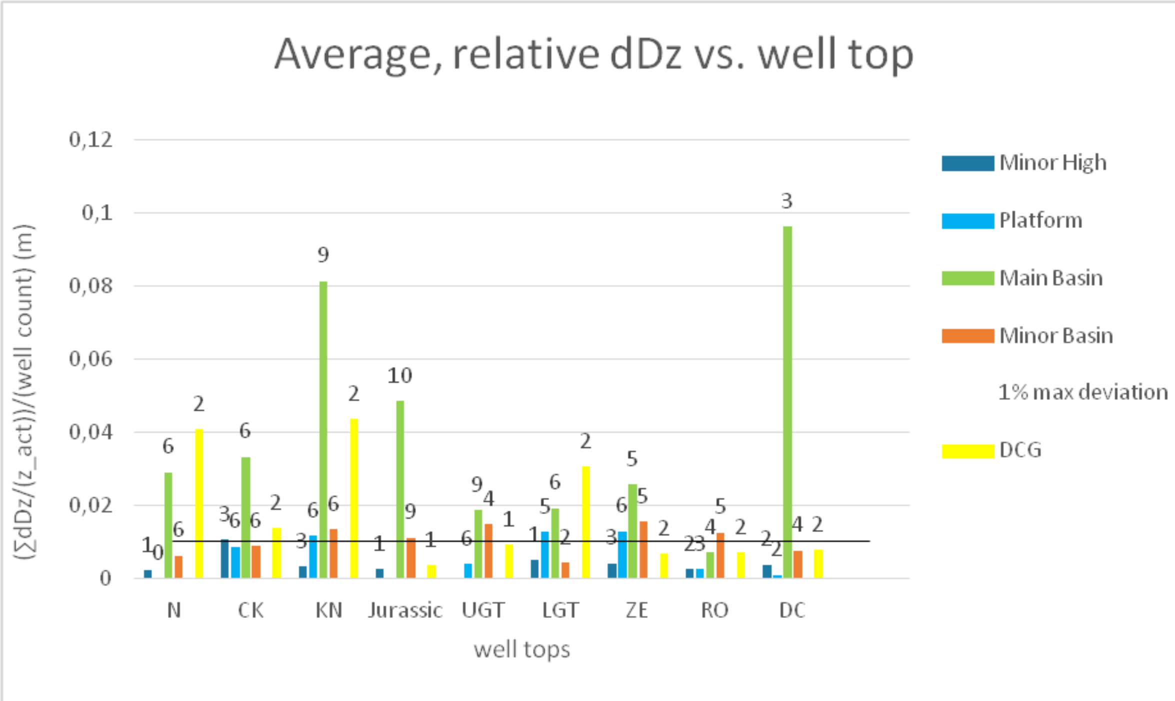

Figure 14 - Average, relative dDz vs. well top for the structural elements Platform (Cleaverbank Platform), Minor High (Cleaver Bank High), Minor Basin (Terschelling Basin and Vlieland Basin), Main Basin (Broad Fourteens Basin and West Netherlands Basin) and Dutch Central Graben (DCG), after similarities in structural characteristics and geological history. Bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units.

It is apparent that for the Platform (fig. 50), Minor High (fig. 51) and Minor Basin (fig. 54), large differences in T2Dcon error magnitude and type exist within a small area (see appendix 2: 'Bar diagrams of T2Dcon errors for individual wells').

- For the DCG (fig. 52), large T2Dcon errors exist for the southern edge of the DCG (L05-08 and L05-B-03), relative to the center (F17-08-S1). Furthermore, whereas F17-08-S1 has large absolute Dz for the stratigraphically deepest well tops its relative Dz T2Dcon errors are significantly smaller.
- Largest and most consistent errors for Main Basin exist for top KN. This is because the Chalk is notoriously difficult in T2Dcon.
- For the Minor Basin, top KN, Jurassic and ZE have the largest and most consistent errors.
- For relative dDz vs. well top analysis, dDz T2Dcon errors for the Minor High are mostly significantly lower than Dz T2Dcon errors.
- For the DCG, dDz T2Dcon errors are often equal or smaller for all wells compared to Dz.
- For the Minor Basin, dDz T2Dcon errors of top ZE have decreased compared to Dz.
- For relative dDz vs. well top analysis, dDz T2Dcon errors for the Minor High are mostly significantly lower than Dz T2Dcon errors.
- For the DCG, dDz T2Dcon errors are often equal or smaller for all wells compared to Dz.
- For the Minor Basin, dDz T2Dcon errors of top ZE have decreased compared to Dz.

T2Dcon methods

Information regarding methods of T2Dcon has been obtained from the EBN documentation and personal feedback at Wintershall.

Wintershall uses Geovel(?) to determine which velocity model best suites the corresponding seismic velocities (personal communication Wintershall B.V.). Generally, V_0k is maintained for T2Dcon (e.g. for the K18-Golf field, F17 block; top RO, the Q04 block, well L08-P4-02-S1, after EBN documentation), which may be based on interval velocities.

T2Dcon difficulties

Information regarding sources of T2Dcon errors have been obtained from the EBN documentation and personal feedback at Wintershall.

T2Dcon problems are related to complex geology (intensely deformed subsurface sections; tilted and faulted (figure 15, 16) or inverted crust. Halokinesis (figure 17) and other stress-induced features are likely to affect basins rather than platforms or highs, although Cleaver Bank High faults have been subject to reactivation). Compaction and diagenesis in general are causes of T2Dcon errors (e.g. L05-08, Q01-26-S2 and D12-A-02, the latter which shows lower than normal porosity, according to the Appraisal D12-A-02 drilling programme document, for the Triassic stratigraphy which may indicate that it has been compacted). Employment of incorrect velocity models and seismic reflector mispicks (which for this analysis have been corrected for) are further sources of T2Dcon errors. Furthermore, deep, thin layers are not resolved by processing velocities (e.g.: in Q04-C-01 the NMRF (Rupel Formation) is 22m thick); T2Dcon errors are however lower in thin layers. Presence of little sonic and VSP's (Vertical Seismic Profile) data, for the North Sea Group in particular, leads to reduced well control. Wildcat wells cannot be compared to nearby wells, reducing well control (F17-08-S1; although it is located within an area in which earlier wells, property of Wintershall, have been drilled). Base Zechstein (Top Rotliegendes) mispicks can be caused by anhydrite floaters which have impact on the seismic velocity. A deviated well-path can also be caused by increased hardness of a formation rock, in which case a drill-bit does not directly penetrate the formation, but moves adjacent to the layering and subsequently penetrates the formation in another location (deep to prognosis). Dated wells which have been T2D converted with the aid of 2D seismics (instead of 3D seismics) are prone to T2Dcon errors.

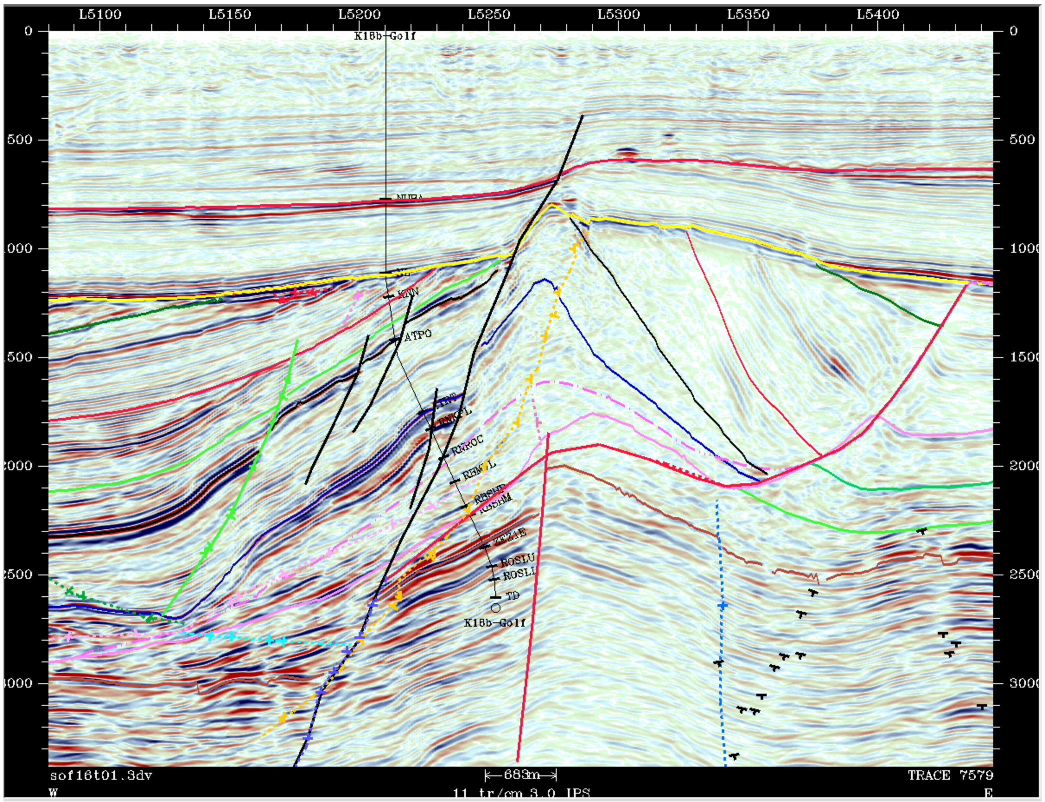

Figure 15 – Example of how the presence of a fault (in well K18-07) may cause large T2Dcon errors. The well intersects the seismic reflector of the top ATPO (Posidonia Shale Formation) and RNKP (Keuper Formation) in an area close to a fault surface. A minor lateral change in the interpretation of the fault may lead to interpreting the underlying and/or overlying layers with greater or smaller thickness. For ATPO, the fault cannot be the main control on the T2Dcon error, because overlying and underlying well tops do not yield a small T2Dcon error. Moreover, the stratigraphy has been tilted. Slight well-path deviations cause large T2Dcon errors in steep-layered stratigraphy.

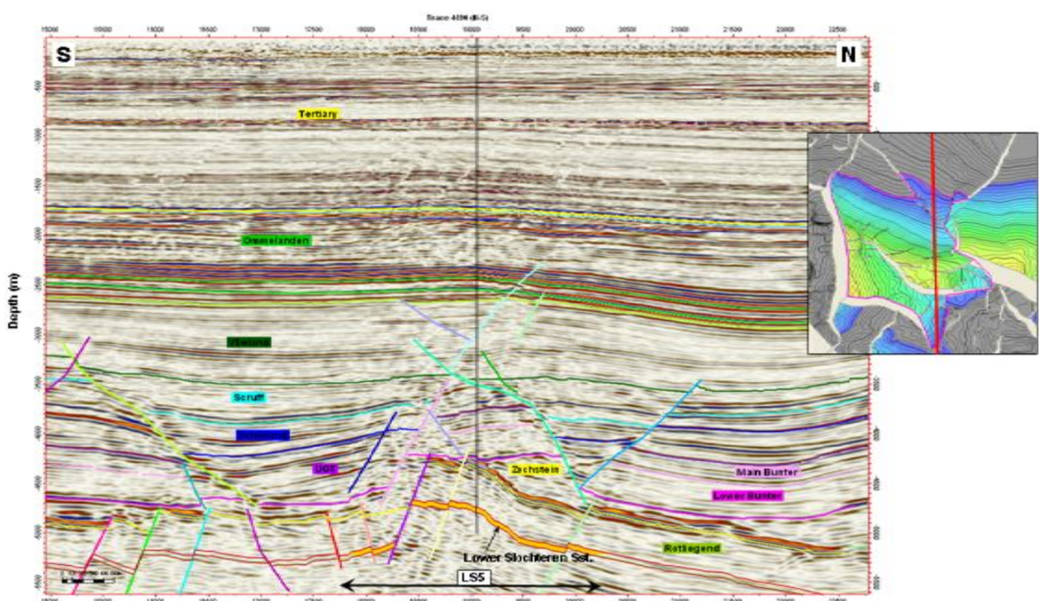

Figure 16 – Example of how the presence of a fault in the well L06-08 could cause large T2Dcon errors. The well intersects the seismic reflector of the top SG in an area close to a fault plane.

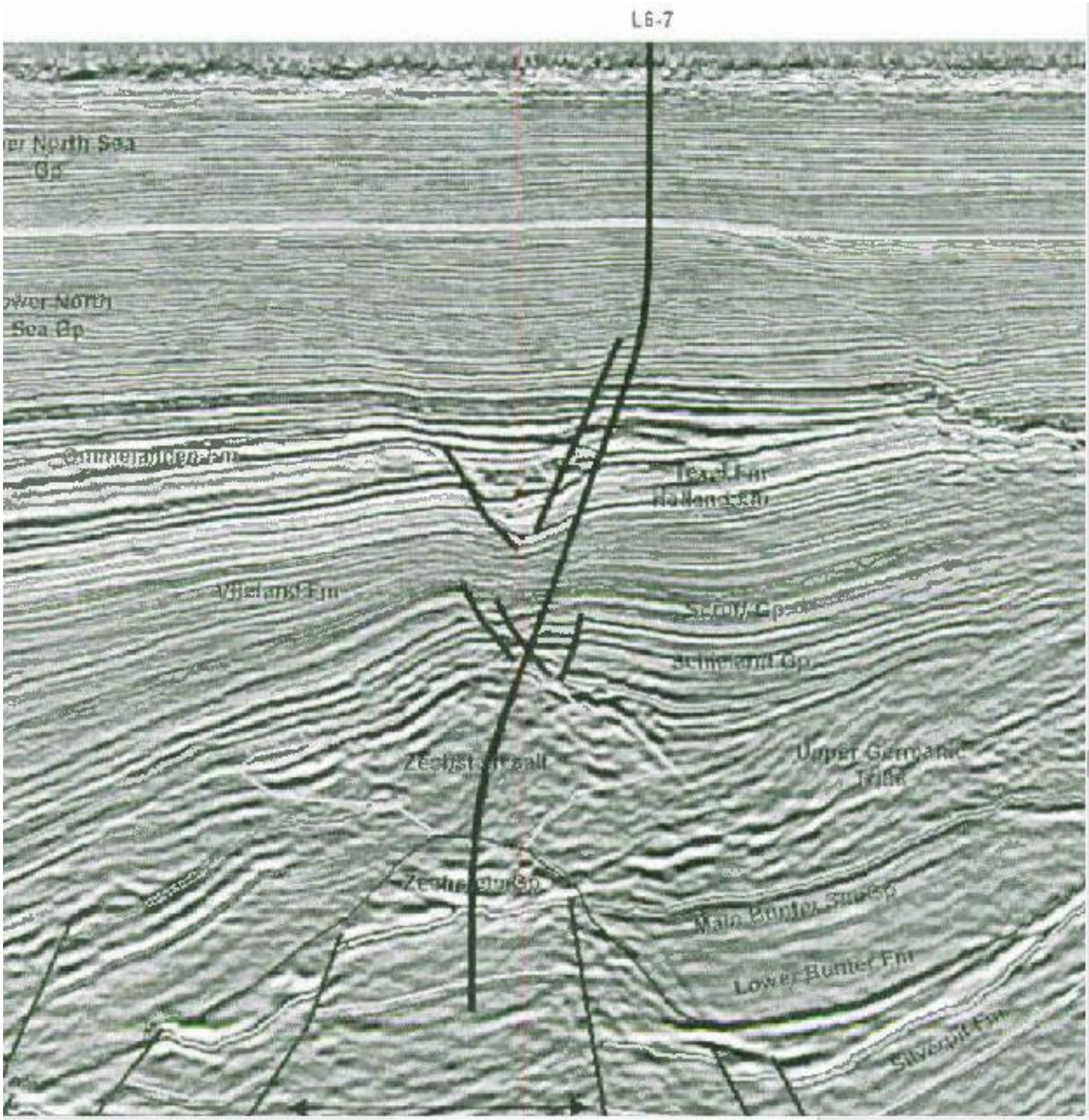

Figure 17 – An example of a subsurface section in which the Jurassic has been uplifted and stressed by the underlying salt intrusion for well L06-07. Stress may affect velocity in upper layers (Jurassic, Cretaceous).

For ENGIE

For ENGIE, 56 wells have been selected for Spotfire and 24 wells (only partly identical to the wells for Spotfire) have been selected for Excel analysis. The analysis has been presented to ENGIE.

Geological Setting and location of the analyzed wells

Figure 18 shows the location of the wells analyzed by Spotfire and Excel. Individual analyses of wells by Excel are summarized in the appendices in alphabetical order. Tables 5-8 (appendix 3) show the corresponding T2Dcon error values per well.

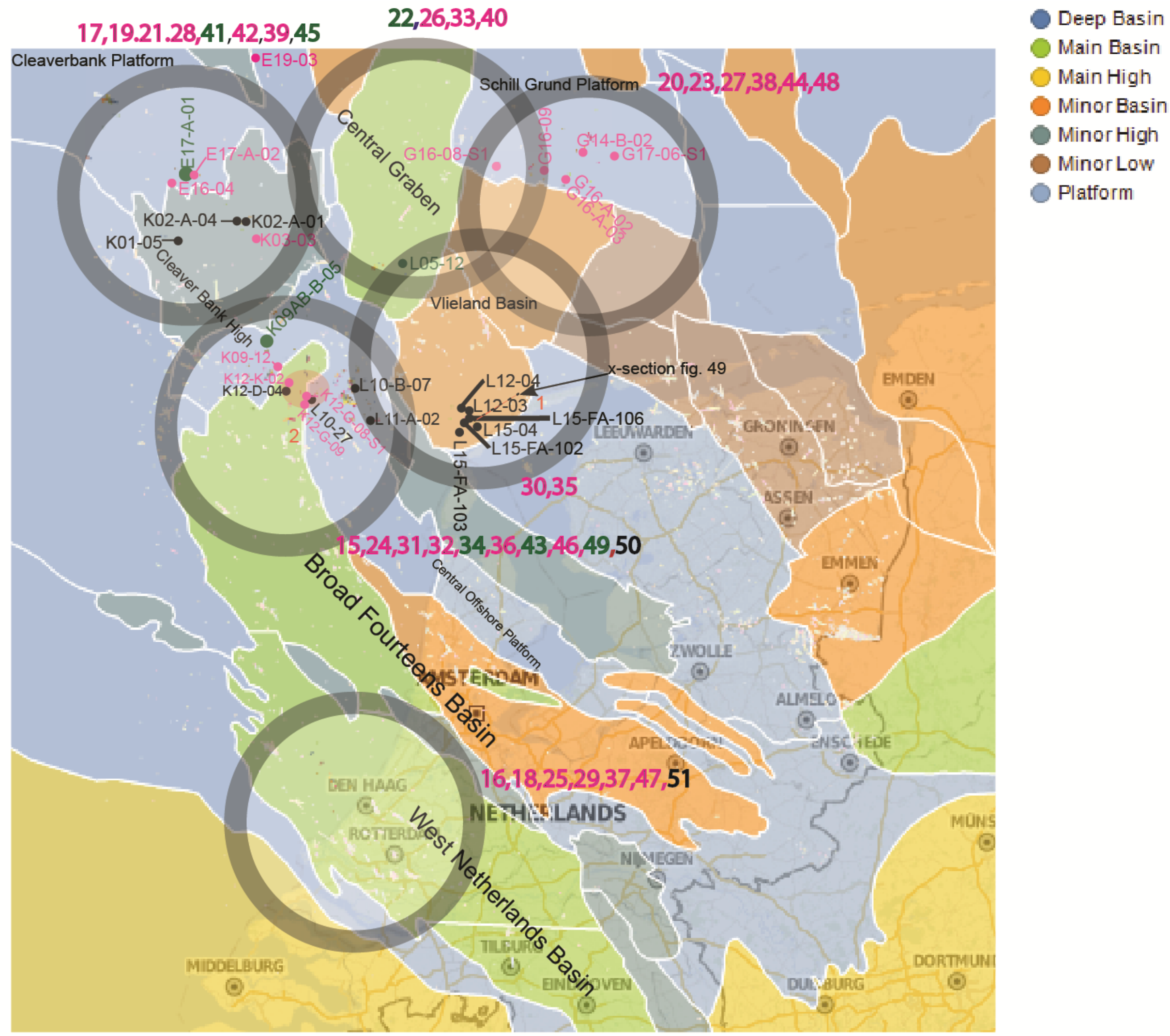

Figure 18 - The location of the wells analyzed with Spotfire (in pink), Excel (in black), and with both Spotfire and Excel (in green). The wells used for analysis have been labeled with their corresponding well name; these amount to 56. Confidential wells have been labeled with a single digit and assigned an approximate location, the range of which is indicated with opaque, black-rimmed circles. Analyzed wells are certainly located in the Broad Fourteens Basin, West Netherlands Basin and Central Graben (all Main Basin), Vlieland Basin (Minor Basin), Cleaverbank Platform, Central Offshore Platform and Schill Grund Platform (all Platform) and the Cleaver Bank High (Minor High). Red, numbered, opaque ellipses and circles and solid dots indicate areas (or specific wells) that have largest T2Dcon difficulties. These are located in the Vlieland Basin, Broad Fourteens Basin/Central Offshore Platform and well 41. See the 'General Discussion' (pp. 47-48) for an explanation.

Spotfire analysis

Exploration wells yield largest average Dz (fig. 19).

Primary targets in the Rijnland Group (KNN and KNNS) yield large errors (but are based on a low amount of wells, for both: 2, see fig 20), Lower Germanic Trias Group primary targets (RB: 1 well, RBMD: 2 wells, RBMV: 7 wells and RBMVL: 2 well) yield large errors. ROSL (2 wells) yield large errors generally, and relative to other Rotliegend Group primary targets.
G16a, G17, L05a and Q13 (although shallow)-licensed wells yield largest Dz (fig. 21). Well 49 yields a large Dz.

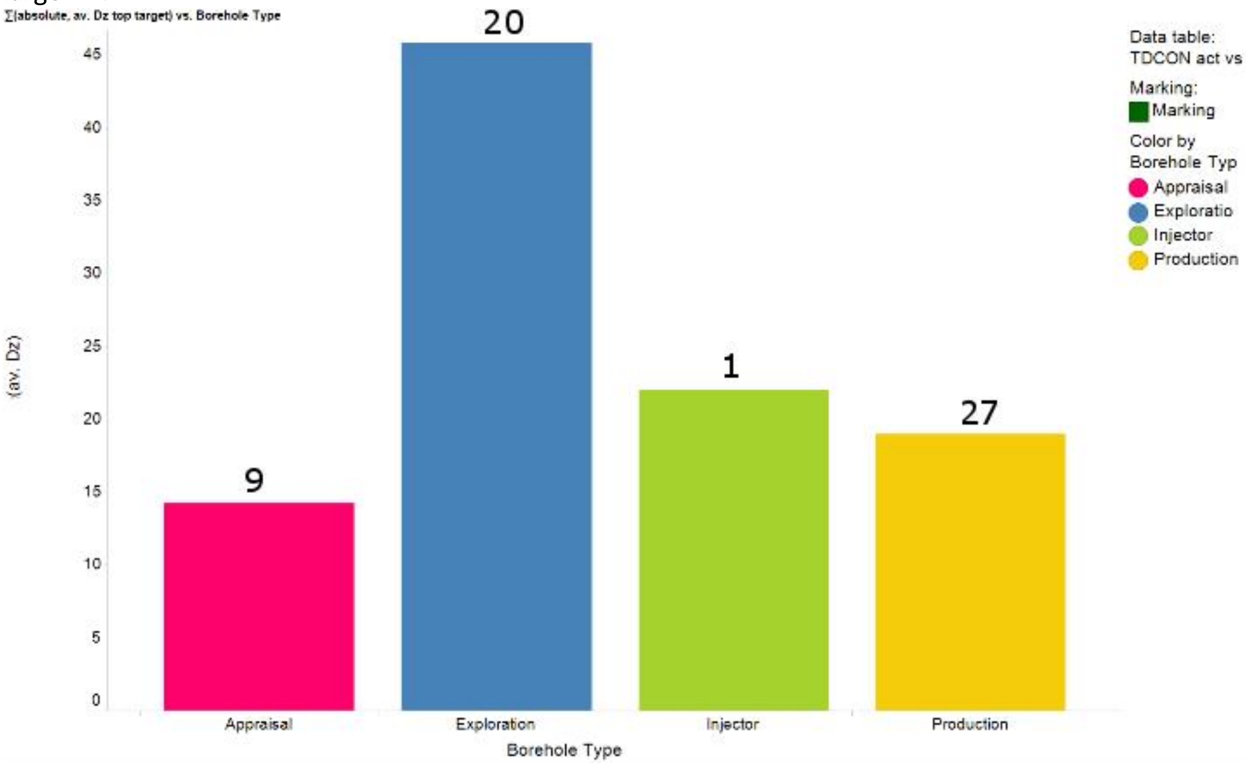

Figure 19 - Average, absolute Dz vs. Borehole Type. Analysis input is derived from 'TDCON act vs prog 2015.xlsm'.Numbers above bars represent well type count.

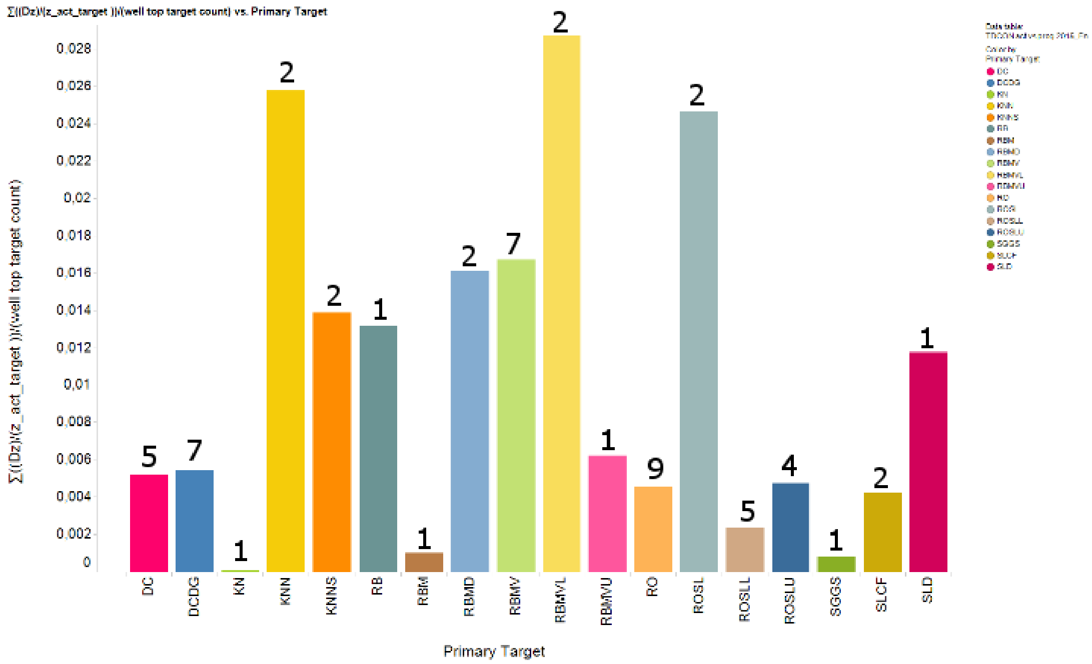

Figure 20 - Absolute $\frac{\sum(\frac{Dz}{z\_act\_target})}{well\ top\ target\ count}$ *vs. Primary Target bar chart. The division of T2Dcon error* Dz *by actual depth per well is enumerated for all primary targets and subsequently divided by the count of well top targets. The legend provides well primary targets. Numbers above bars represent Primary Target count. Analysis input is derived from 'TDCON act vs prog 2015.xlsm'. DC = Limburg Group, DCDG = Hospital Ground Formation, KN = Rijnland Group, KNN = Vlieland Subgroup, KNNS = Vlieland Sandstone Formation, RB = Lower Germanic Trias Group, RBM = Main Buntsandstein Subgroup, RBMV = Volpriehausen Formation, RBMVL = Lower Volpriehausen Sandstone Member, RBMVU = Upper Volpriehausen Sandstone Member, RO = Upper Rotliegend Group, ROSL = Slochteren Formation, ROSLL = Lower Slochteren member, ROSLU = Upper Slochteren Member, SLCF = Friese Front Formation, Delfland Group.*

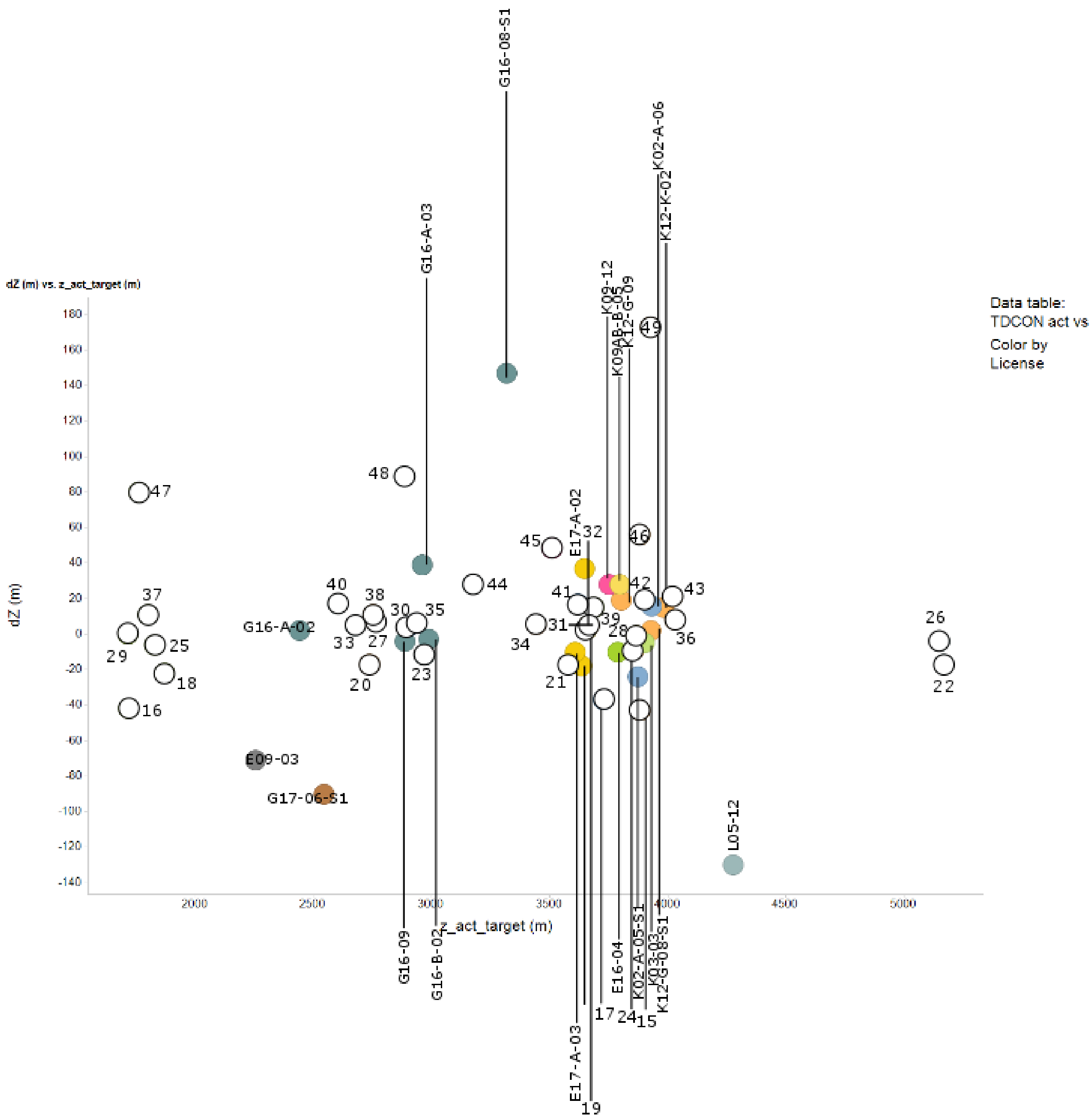

Figure 21 - Dz vs. z_act_target (target depth) scatter plot for labeled ENGIE wells analyzed with Spotfire. Not all data points have been labeled because some data points overlap. Colors indicate different the well licenses. Confidential wells have been labeled with a single digit (as in fig. 18). The diagram considers additional T2Dcon errors due to increasing target depth (e.g.: a well with Top target delta ~0 at considerable depth has been excellently T2D converted). Analysis input is derived from 'TDCON act vs prog 2015.xlsm'. See the report text for a discussion of the diagram.

Excel analysis

Fig. 22 and 23 show average, relative Dz vs. well top and average, relative dDz vs. well top, respectively. Bars are calculated by $\frac{\sum \frac{\mathrm{Dz}}{\mathrm{z\_act}}}{\text{well top count}}$ and $\frac{\sum \frac{\mathrm{dDz}}{\mathrm{z\_act}}}{\text{well count}}$ for fig. 22 and 23, respectively. Figure 22 illustrates that wells in the Main Basin and Platform (see page 10 for the subdivision of structural elements used in this report) generally yield largest T2Dcon errors (especially for the stratigraphically deepest well tops except top DC). Top KN and ZE yield large errors in general.

Top UGT (Upper Germanic Trias Group) yields large T2Dcon errors for the Platform (although this is based on a low amount of wells: 2).

From figure 22 to 23, the error for top ZE is decreased, the error for top RO is increased and the error for top KN (Rijnland Group) in the Main Basin is decreased. Dz and dDz T2Dcon errors are of the same order of magnitude (with exceptions for Minor Basin top Jurassic and top RO generally, fig. 23). Top RO dDz T2Dcon error is larger than top RO Dz for all structural elements.

Whenever well tops are based on confident seismic markers, it would be more meaningful to use Dz instead of dDz, because in that case there is no need to depth-correct with dDz.

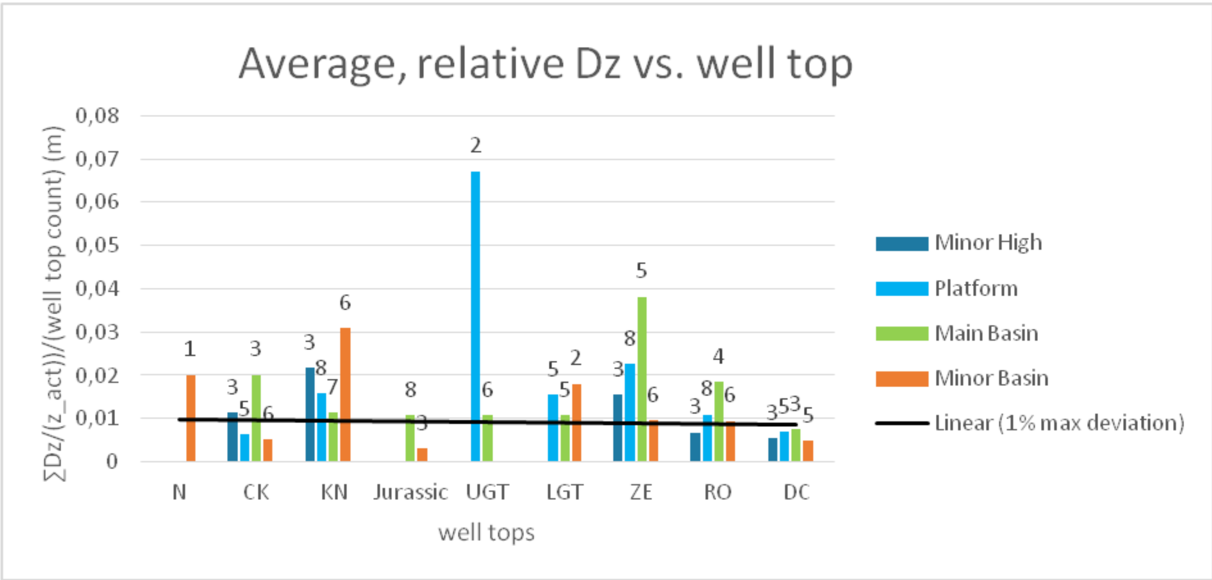

Figure 22 - Average, relative Dz vs. well top for the structural elements shown in fig. 18. Bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text for a discussion of the diagram.

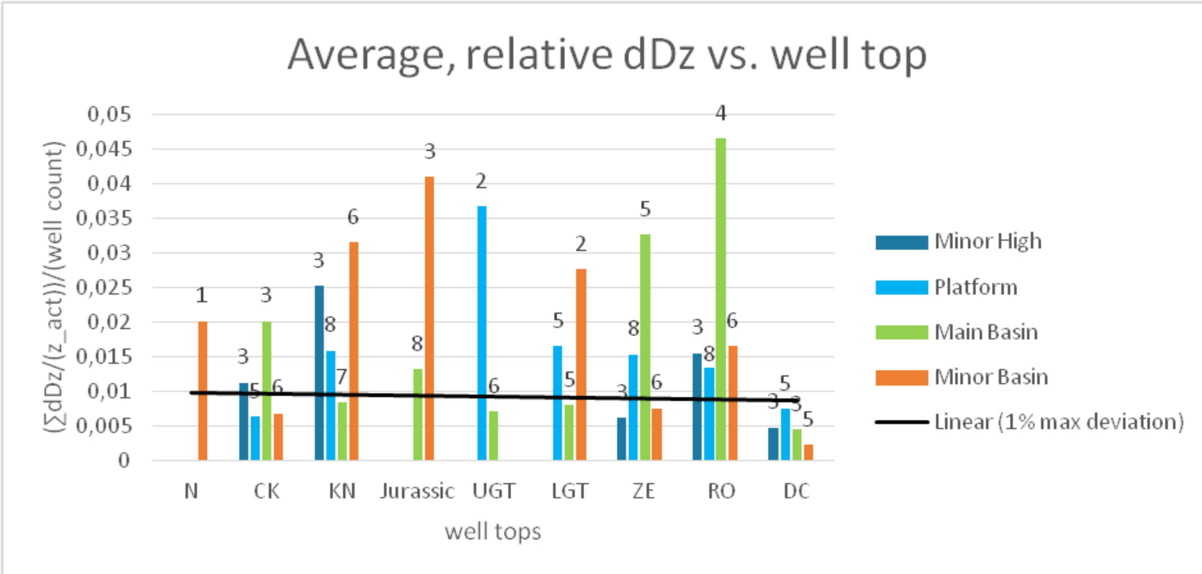

Figure 23 - Average, relative dDz vs. well top for the structural elements related to fig. 18. Bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. Note scale difference from fig. 8. See appendix 4 for a list of abbreviations of the stratigraphic units.

The following analysis is based on a more detailed subdivision of the combined structural elements: Platform (Cleaverbank Platform and Central Offshore Platform), Minor High (Cleaver Bank High), Minor Basin (Vlieland Basin), Main Basin (Broad Fourteens Basin and West Netherlands Basin) and Dutch Central Graben (DCG).

Discussion of features will be restricted to the Main Basin and DCG structural elements. It must be noted that analysis of DCG is generally based on a small database and increasingly meaningful results will be obtained in enlarging this database.

The Main basin generally yields larger T2Dcon errors than the DCG (except for top UGT and top LGT). This is possibly associated with increased salt-related issues in the Broad Fourteens Basin relative to the DCG. Especially, T2Dcon errors for the top ZE are significantly larger in the Main Basin than in the DCG.

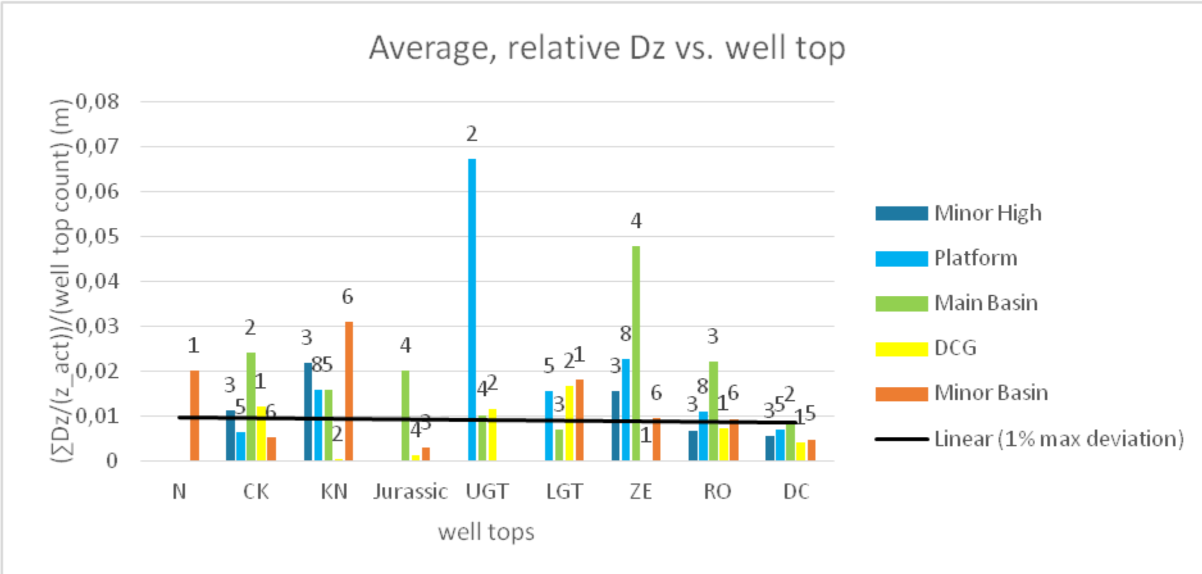

Figure 24 - Average, relative Dz vs. well top for the structural elements Platform (Cleaverbank Platform and Central Offshore Platform), Minor High (Cleaver Bank High), Minor Basin (Vlieland Basin), Main Basin (Broad Fourteens Basin and West Netherlands Basin) and Dutch Central Graben, after similarities in structural characteristics and geological history. Bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units.

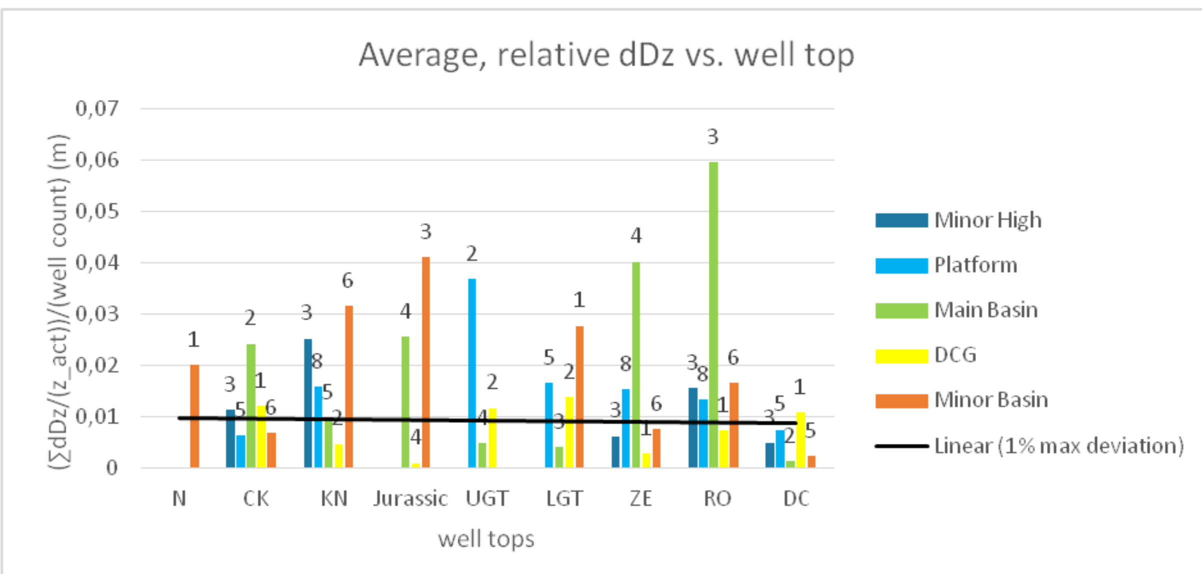

Figure 25 - Average, relative dDz vs. well top for the structural elements Platform (Cleaverbank Platform and Central Offshore Sad Platform), Minor High (Cleaver Bank High), Minor Basin (Vlieland Basin), Main Basin (Broad Fourteens Basin and West Netherlands Basin) and Dutch Central Graben, after similarities in structural characteristics and geological history. Bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units.

Large T2Dcon errors are often attributable to error extremes in individual wells, whereas generally most T2Dcon errors are fairly acceptable (see appendix 2: 'Bar diagrams of T2Dcon errors for individual wells').

- From the difference in type and sign of Dz T2Dcon errors for the Platform (fig. 60), it can be derived that the cause of T2Dcon errors is likely very different for L10-27 relative to the remainder of the wells in the Platform. Furthermore, positive top LGT and ZE T2Dcon errors exist for most wells (fig. 60).
- For the Minor High, all three wells have T2Dcon errors outside the acceptable deviation range (+/- 20m). Largest significant T2Dcon errors are for top KN and ZE.
- For the DCG, significant T2Dcon errors are encountered in Triassic formations of well L05-12. This well suffers from saltplugging of the Bunter reservoir, which will affect velocities in this formation.
- In the Main Basin, it is evident that K12-19 fairly consistently has T2Dcon errors deep to prognosis (negative). For the Jurassic, T2Dcon errors are consistently shallow to prognosis.
- In the Minor Basin (fig. 64) it is evident that large differences in T2Dcon error magnitude and type occur within a small area (L12-03 compared with L12-04).

T2Dcon methods

Information regarding methods of T2Dcon has been obtained from the EBN documentation and personal feedback at ENGIE.

Generally, V_0k is used for T2Dcon, using a layer-cake model.

Other T2Dcon methods and procedures encountered include:

- Joint application of V_0k and interval velocities. This is the case for the Chalk and Zechstein intervals of E18-03 (not used for analysis), because these intervals respond sensitively to lateral velocity variations (T2Dcon of the Zechstein interval of E18-03 is also approached with a wedge model/function. For L15-04 interval velocities maps have been used down to top ZE.
- T2Dcon may have required Pre-stack depth migrated (PSDM) processing velocities to make a velocity model (e.g. for K09AB-B-05).
- For well 41, top RO is a prominent regional marker, which can be T2D converted directly. For well 41, corrections due to pull-up effects of floaters have been applied.
- For K7-FB-102 (not used for analysis), a PSDM depth cube was converted to depth directly and subsequently, kriging was applied to obtain a fit in the wells. Kriging is used in geostatistics to combine 'hard', well data with 'soft', seismic data and compare known combinations of these at locations to predict unknown values at target locations (Etris et al., 2001). It was concluded that PSDM velocities could not confidently pick up (strong) lateral velocity changes in the Triassic.
- T2Dcon for well 34 was based on a seismic survey acquired by GDF SUEZ over the whole of the KandL asset, which was processed in 2010. The data from this survey was Pre-Stack Depth Migrated (PSD Migrated) and T2D converted based on anisotropic Kirchhoff depth migration processing.

T2Dcon difficulties

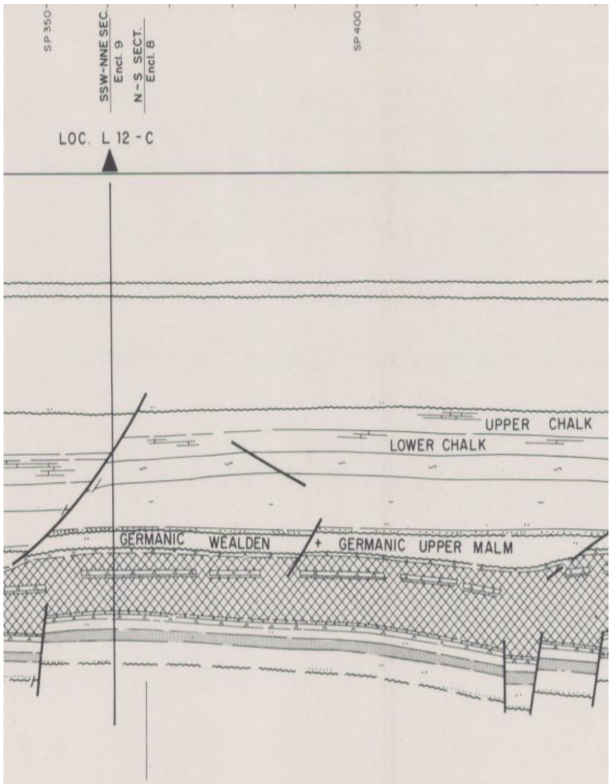

Figure 26 – An example of T2Dcon errors due to faulting. Well L12-03 intersects seismic reflector of top KN in an area close to a fault surface.

Information regarding sources of T2Dcon error has been obtained from the EBN B.V. documentation and personal feedback at ENGIE.

T2Dcon difficulties are related to complex geology. Intensely deformed subsurface sections, tilted and faulted (figure 26, L12-03 and 27, well 49) or inverted crust, halokinesis and other stress-induced features are likely to affect basins rather than platforms or highs. The presence of salt, floaters and anhydrite rafts can cause velocity pull-up due to its high velocity (fig. 28, L10-27 and 29, well 41), seismic reflector mispicks (which for this analysis have been corrected for), compaction and diagenesis in general may all influence T2Dcon. Furthermore, deep, thin layers do not resolve processing velocities; T2Dcon errors are however lower in thin layers). Presence of little sonic and VSP (Vertical Seismic Profile) data leads to reduced well control. Wildcat wells cannot be compared to nearby wells, reducing well control (well 22, for top Triassic and below). Poor (and dated) seismic imaging yields T2Dcon errors (e.g. L10-27).

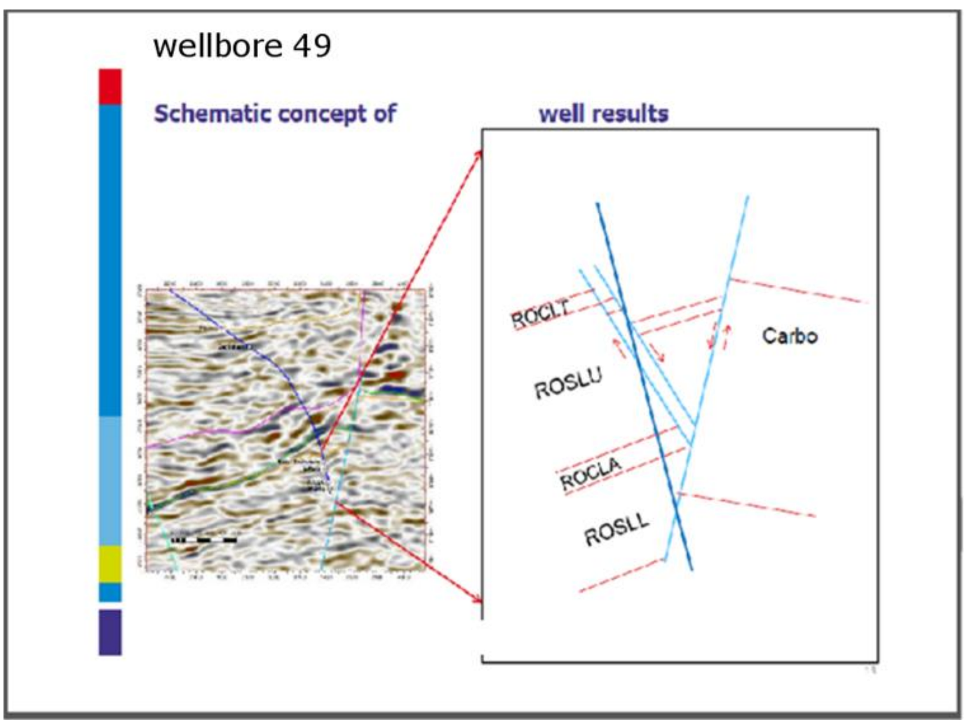

Figure 27- An example of T2Dcon errors due to faulting. The well intersects seismic reflector of top RO in an area close to a fault surface. See appendix 4 for a list of abbreviations of the stratigraphic units.

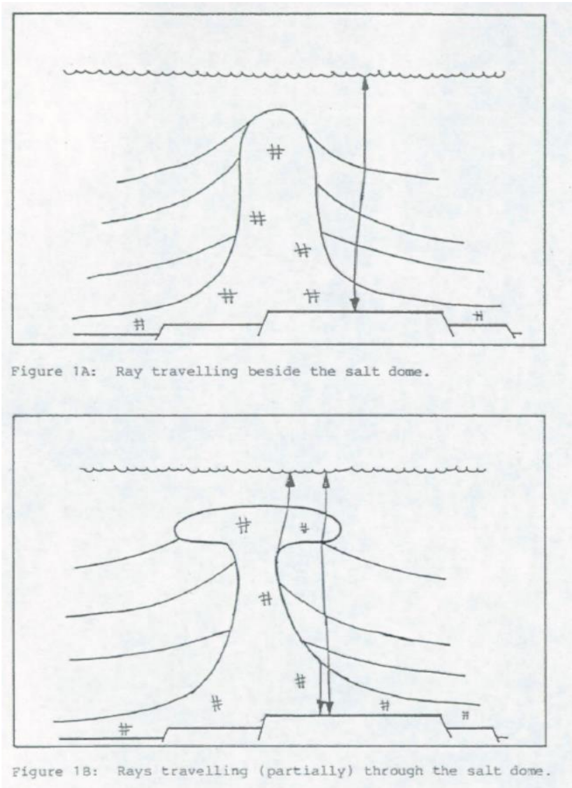

Figure 28 - An example of T2Dcon errors due to salt. Salt-affected ray paths exist for well L10-27 that cause a horizon that is mapped too high in depth.

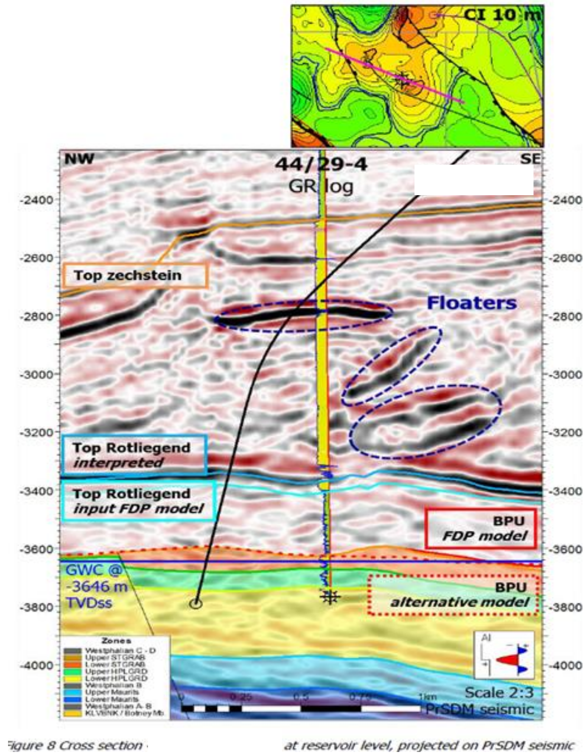

Figure 29 - An example of T2Dcon errors due to salt. Well 22 is located in an area in which floaters (anhydrite rafts) exist. These floaters are much faster than the surrounding rocks.

For NAM

Although NAM did not cooperate with this project, analysis of T2Dcon errors associated with wells with NAM license has been carried out and this will be presented below. For NAM, 67 wells have been selected for Spotfire and 39 wells (only partly identical to the wells for Spotfire) have been selected for Excel analysis.

Geological Setting and location of the analyzed wells

The following figures show the location of the wells analyzed with Excel (fig. 30). An overview of wells analyzed with Spotfire has been excluded, due to the large density of wells. Individual analyses of wells by Excel are summarized in appendix 1 in alphabetical order. Tables 9-12 (appendix 3) contain the corresponding T2Dcon error values per well.

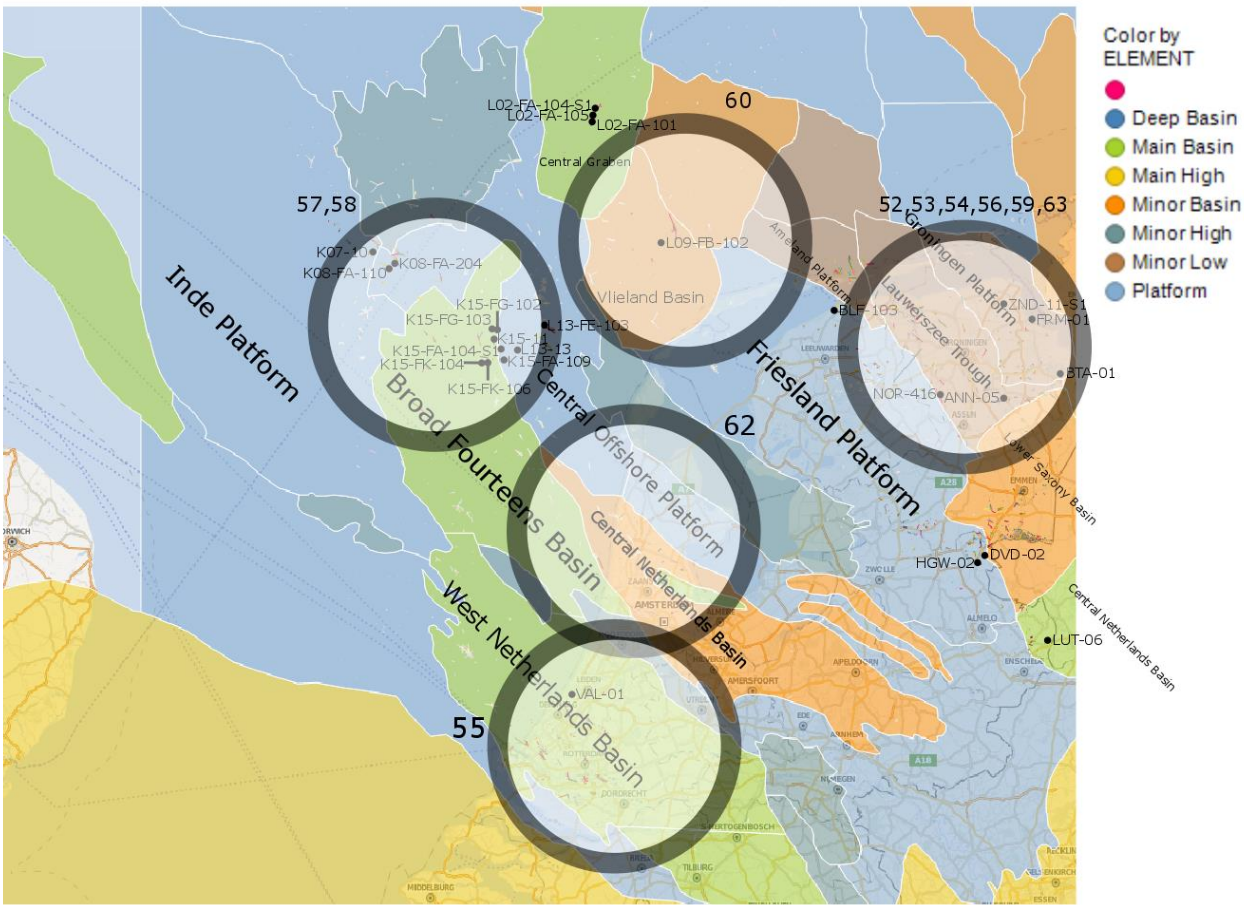

Figure 30 - The location of the NAM-licensed wells analyzed (with the exception of HBG-08 and L02-05) with Excel. The 39 wells used for analysis have been labeled with their corresponding well name. Confidential wells have been labeled with a single digit and assigned an approximate location, the range of which is indicated with opaque, black-rimmed circles. Analyzed wells are certainly located in the Broad Fourteens Basin, West Netherlands Basin, Central Netherlands Basin and Central Graben (all main basins), Vlieland Basin, Central Netherlands Basin and Lower Saxony Basin (all minor basins), Inde Platform, Central Offshore Platform and Friesland Platform (all platforms), Ameland Platform, Lauwerszee Trough and Groningen Platform (all minor lows). The location of the wells analyzed with Spotfire has not been indicated due to the large density of wells analyzed (67). Areas (or specific wells) that have largest T2Dcon difficulties will be discussed. See the 'General Discussion' (pp. 47-48) for an explanation.

TIBCO Spotfire® analysis

Appraisal wells yield the largest average Dz (fig. 31). The Upper Rotliegend Group (including ROSL, ROSLL and ROSLU) yields largest errors, RBMV and RBMVL yield large errors (but are based on a low amount of wells; 2 and 1, respectively, fig. 32). Stratigraphically deepest DCDT (Tubbergen Formation) yields a small error (but is based on 1 well). Wells with DRENTHE II and K15 licenses have largest Dz. Other licenses do not have large Dz (see fig. 33).

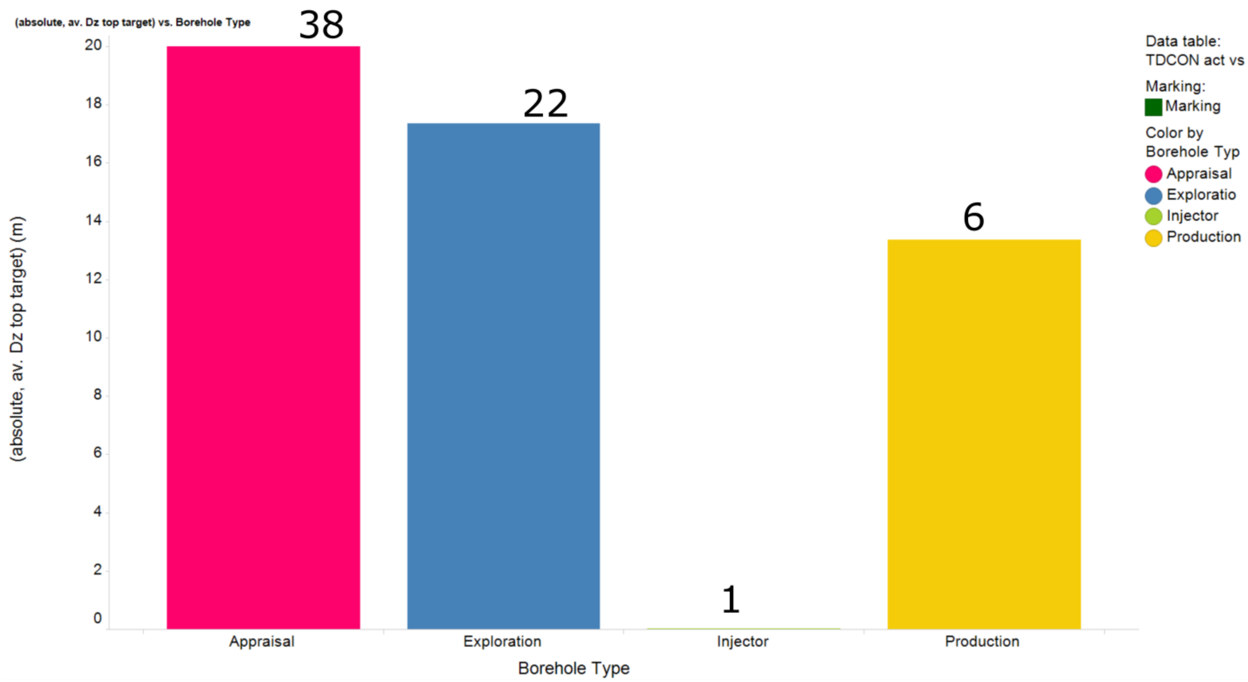

Figure 31 - Average, absolute Dz vs. Borehole Type. Analysis input is derived from 'TDCON act vs prog 2015.xlsm'. Numbers above bars represent well type count.

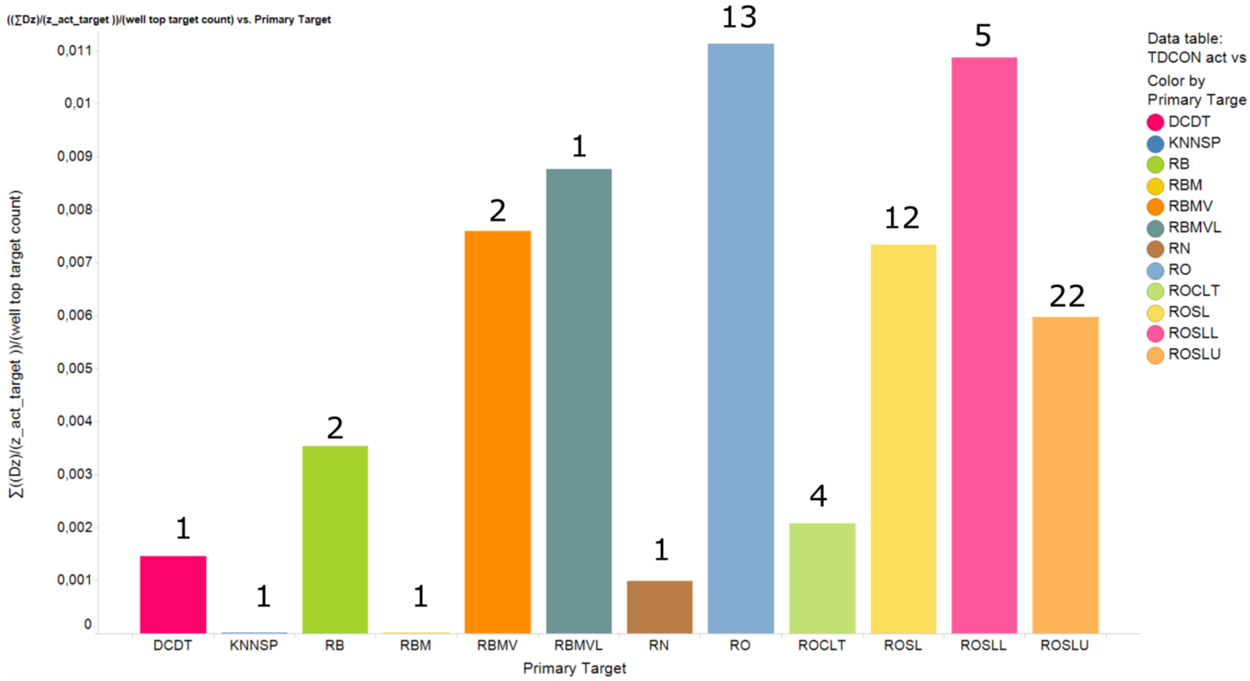

Figure 32 - Absolute $\frac{\sum(\frac{Dz}{z\_act\_target})}{well\ top\ target\ count}$ *vs. Primary Target bar chart. The division of T2Dcon errors* Dz *by actual depth per well is enumerated for all primary targets and subsequently divided by the count of well top targets. The legend provides well Primary Target. Numbers above bars represent Primary Target count. Analysis input is derived from 'TDCON act vs prog 2015.xlsm'. DCDT = Tubbergen Formation, KNNSP = Bentheim Sandstone Member, RB = Lower Germanic Trias Group, RBM = Main Buntsandstein Subgroup, RBMV = Volpriehausen Formation, RBMVL = Lower Volpriehausen Sandstone Member, RN = Upper Germanic Trias Group, RO = Upper Rotliegend Group, ROCLT = Ten Boer Member, ROSL = Slochteren Formation, ROSLL = Lower Slochteren member, ROSLU = Upper Slochteren Member.*

Figure 33 – Dz vs. z_act_target (target depth) scatter plot for 67 NAM wells. Wells have not been labeled due to large density of data points. The legend provides well licenses. The diagram considers additional T2Dcon errors due to increasing target depth (e.g.: a well with Top target delta ~0 at considerable depth has been excellently T2D converted). Analysis input is derived from 'TDCON act vs prog 2015.xlsm'.

Excel analysis

Fig. 34 and 35 show the average, relative Dz vs. well top and the average, relative dDz vs. well top, respectively. From figures 34 and 35 it is evident that wells in the Main Basin and the Platform have largest T2Dcon errors, often for most well tops. Stratigraphically shallowest well tops (North Sea Group and Chalk Group) have largest T2Dcon errors in general (and for the Platform, mainly). Apart from these, the Jurassic and DC have the high values for T2Dcon errors.

For the Main Basin, T2Dcon errors decrease from the top Jurassic-RO, while T2Dcon errors increase in these formations, for wells in the Platform (see page 10 for the subdivision of structural elements used in this report). Minor Low (and Minor Basin) wells often fall in the accepted range (+/-20m) of T2Dcon errors (certainly for fig. 35).

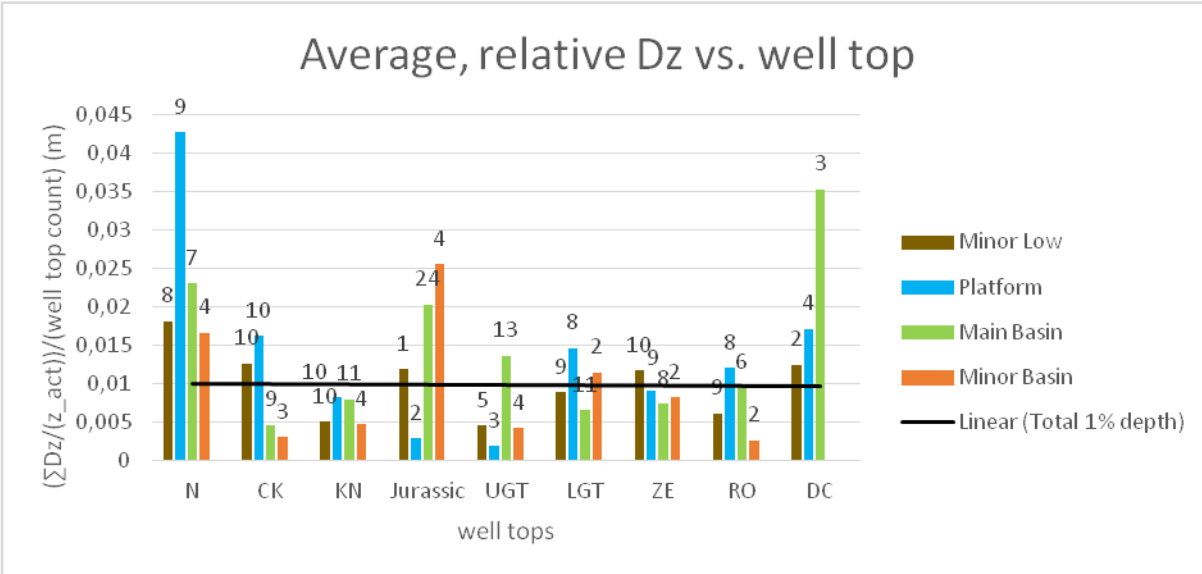

Figure 34 - Average, relative Dz vs. well top for the structural elements related to fig. 30. The bars are based on absolute values for T2Dcon errors. Numbers above the bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units.

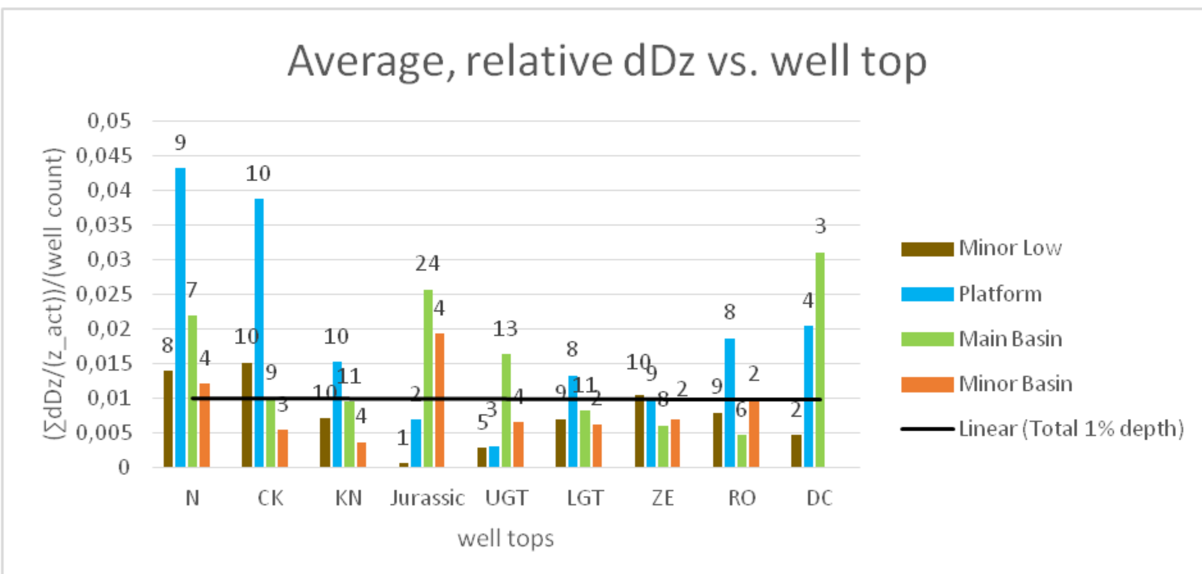

Figure 35 - Average, relative dDz vs. well top for the structural elements related to fig. 30. The bars are based on absolute values for T2Dcon errors. Numbers above the bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units.

For the following analysis a more detailed subdivision of the combined structural elements is used based on similarities in structural characteristics and geological history: Minor Low (Ameland Platform, Lauwerszee Trough and Groningen Platform), Platform (Central Offshore Platform, Friesland Platform and Inde Platform), Main Basin (Broad Fourteens Basin and West Netherlands Basin), Minor Basin (Vlieland Basin) and the combination DCG+CNB+LSB (Dutch Central Graben [DCG], Central Netherlands basin [CNB] and Lower Saxony Basin [LSB]). Discussion of features will be restricted to the Main Basin, Minor Basin and DCG+CNB+LSB structural element combinations only, because for this analysis only

these have been reorganized. It must be noted that analysis of the Minor Basin is generally made on a small database and more meaningful results could be obtained by enlarging this database.
From both figures it is obvious that generally the Broad Fourteens Basin and West Netherlands Basin have largest T2Dcon errors for the stratigraphically shallowest well tops, whereas DCG+CNB+LSB have largest T2Dcon errors for the stratigraphically deep tops. Large top Jurassic and DC (while only based on 1 well) T2Dcon errors are restricted to the DCG+CNB+LSB, rather than the Main Basin.

Due to this reorganization, the Vlieland Basin does not contain top Jurassic data, but top KN T2Dcon errors for the Minor Basin have significantly increased (though still within the acceptable deviation).

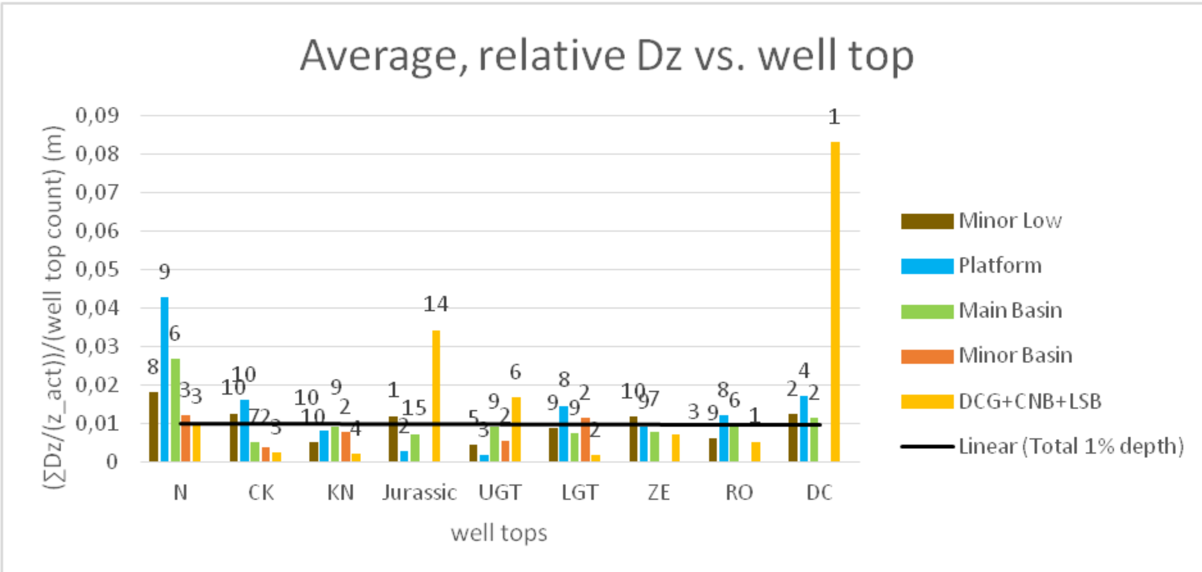

Figure 36 - Average, relative Dz vs. well tops for the structural elements Platform (Central Offshore Platform, Friesland Platform and Inde Platform), Minor Low (Ameland Platform, Lauwerszee Trough and Groningen Platform), Minor Basin (Vlieland Basin), Main Basin (Broad Fourteens Basin and West Netherlands Basin) and DCG+CNB+LSB (Dutch Central Graben, Central Netherlands basin and Lower Saxony Basin), after similarities in structural characteristics and geological history. The bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units.

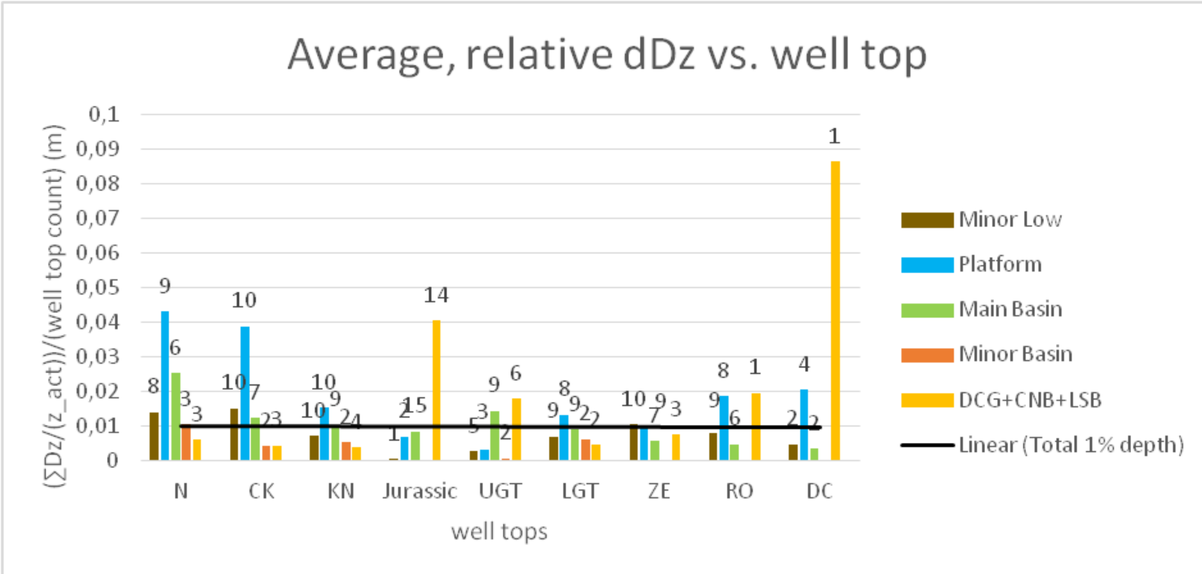

Figure 37 - Average, relative dDz vs. well top for the structural elements Platform (Central Offshore Platform, Friesland Platform and Inde Platform), Minor Low (Ameland Platform, Lauwerszee Trough and Groningen Platform), Minor Basin (Vlieland Basin), Main Basin (Broad Fourteens Basin and West Netherlands Basin) and DCG+CNB+LSB (Dutch Central Graben, Central Netherlands basin and Lower Saxony Basin), after similarities in structural characteristics and geological history. Bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units.

From the analysis shown in appendix 2: 'Bar diagrams of T2Dcon errors for individual wells' it follows that:

- Several wells have large T2Dcon errors for top N, which leads to considering whether these errors are related to geological complexities or other parameters, such as limited or poor seismic imaging.
- LUT-06 is responsible for the top DC T2Dcon error for DCG+CNB+LSB, while LUT-06, well 62, L02-FA-104-S1 and L02-FA-101 cause T2Dcon errors for top Jurassic for DCG+CNB+LSB. LUT-06 and well 62 are both located in the CNB, which implies that the CNB appears to have larger difficulties in the prognosis of top CNB, relative to the DCG. The Lower Saxony Basin well 54 does not have large T2Dcon errors which may imply that it shows distinct geological characteristics from the other wells.
- The West Netherlands Basin wells have consistently the largest T2Dcon errors for top KN and top Jurassic (fig. 71 and 76). For the Main Basin (fig. 71) it is evident that large differences in T2Dcon errors in both magnitude and cause of error exist within a small area (between K15-FG-102, K15-FG-103 and K15-11). For K15-DF-102, most T2Dcon errors are deep to prognosis, which may indicate that more severe compaction has played a role and hence inversion was more severe than anticipated. K15-FG-103 has large errors for Triassic well tops (fig. 71 and 76).
- Well 57 has largest T2Dcon errors for the Platform, for well tops CK, KN, LGT and RO (fig. 72 and 77).
- For the Minor Low, T2Dcon errors are consistently encountered for most wells for top CK, LGT and ZE, both shallow and deep to prognosis. Well BTA-01 consistently shows T2Dcon errors deep to prognosis implying that this may be related to larger than expected compaction.

T2Dcon methods

NAM often employs the $V_o k$ method for T2Dcon, using interval velocities.

Wherever well shoot and log data lack, the position of seismic reflectors has been based on regional information (i.e. for shallow seismic reflectors of LUT-06).

T2Dcon difficulties

Information regarding sources of T2Dcon errors has been obtained from the EBN documentation. NAM did not want to cooperate with interviews.

T2Dcon difficulties are often related to complex geology (intensely deformed subsurface sections; tilted and faulted (fig. 38, 39) or inverted sections (fig. 38). Effects of compaction are generally related to inversion and compaction and diagenesis in general are both causes of T2Dcon errors. Halokinesis may have caused T2Dcon errors (more specifically, potentially for the K15-block and DCG wells). Seismic reflector mispicks (which for this analysis have been corrected for) are sources of T2Dcon errors. Presence of little sonic and VSP's (Vertical Seismic Profiles), in particular – but not restricted to - the North Sea Group, leads to reduced well control. Wildcat wells cannot be compared to nearby wells, reducing well control (e.g. FRM-01). Dated wells which have been T2D converted with the aid of 2D seismic (instead of 3D seismic) are prone to T2Dcon errors.

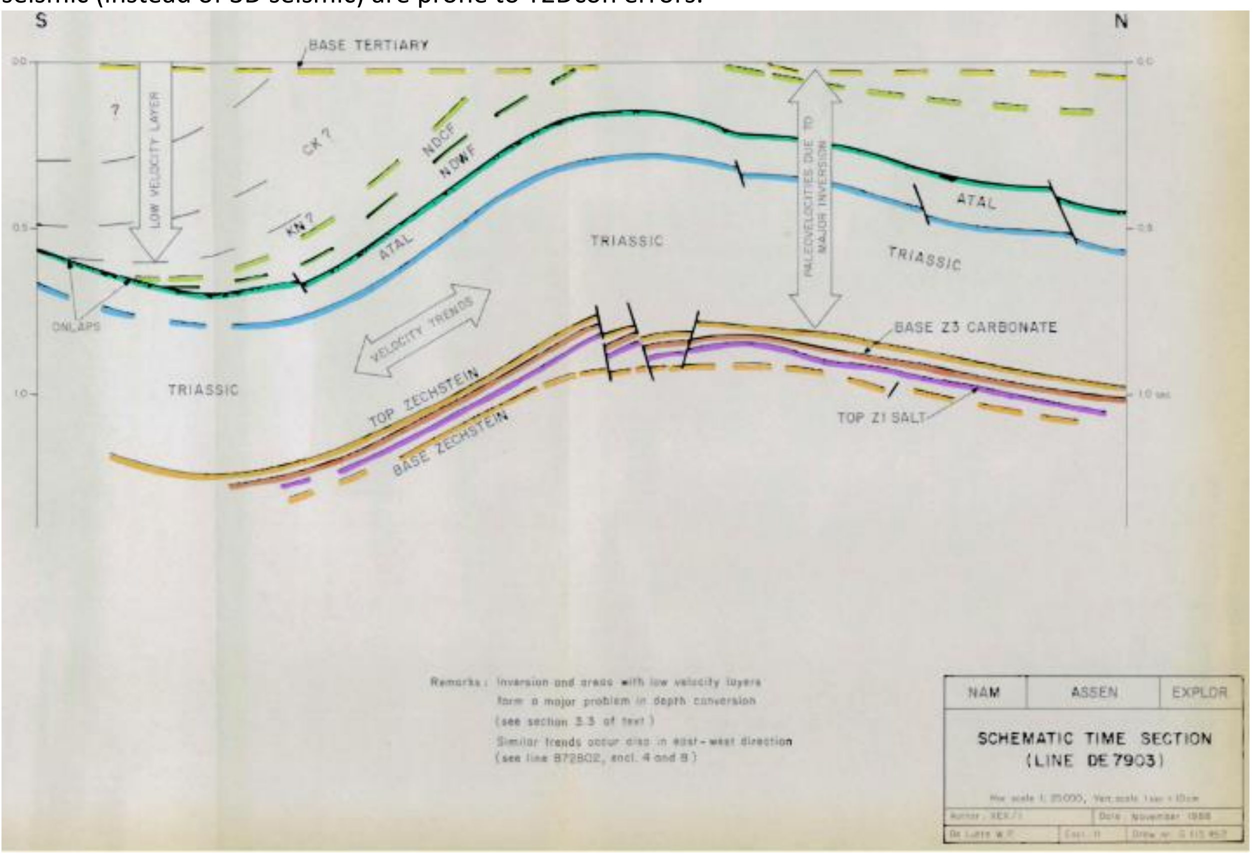

Figure 38 – Cross-section of the De Lutte area. Faulting exists in the Zechstein Group. Inversion led to the generation of a complex fault pattern at base Altena Group and in layers above that, affecting the entire post Triassic section up to the Tertiary. Moreover, lateral velocity differences are an additional effect of inversion. These effects complicate T2Dcon.

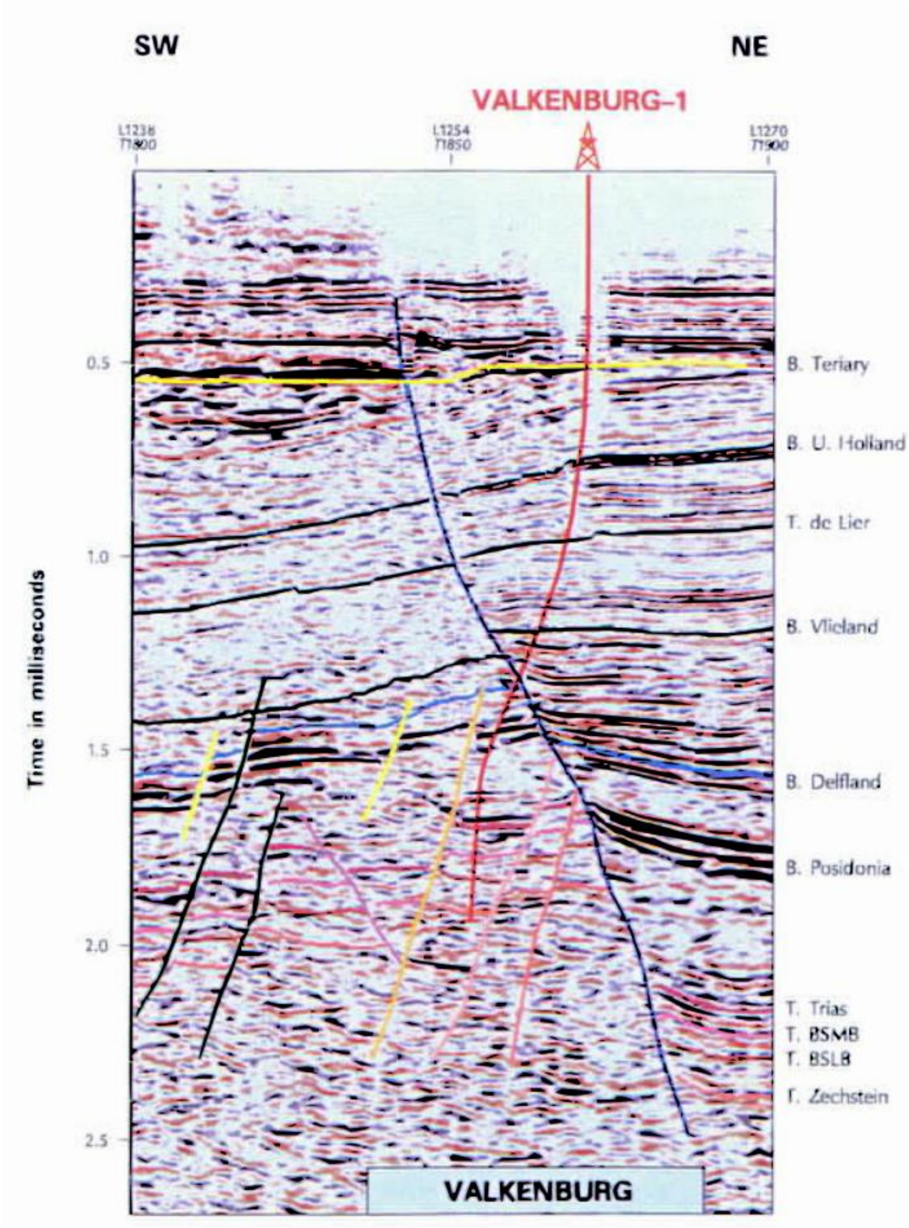

Figure 39 - Example of how the presence of a fault in well (VAL-01) may cause large T2Dcon errors. The well intersects the seismic reflector of the top Delfland (Jurassic) in an area close to a fault surface.

Combined analysis

Because wells have been selected in the Main Basin (Broad Fourteens Basin and West Netherlands Basin), DCG and Vlieland Basin for all three operators Wintershall, ENGIE and NAM, average, relative Dz and dDz analyses for these structural elements for the three operators is combined and presented below. Subsequently, Dz and dDz T2Dcon errors for these structural elements are presented for the three operators separately; the results are combined in a single diagram (fig. 42-44 and fig. 46-48) per structural element. Figure 40 indicates the location of the wells used for combined analysis.

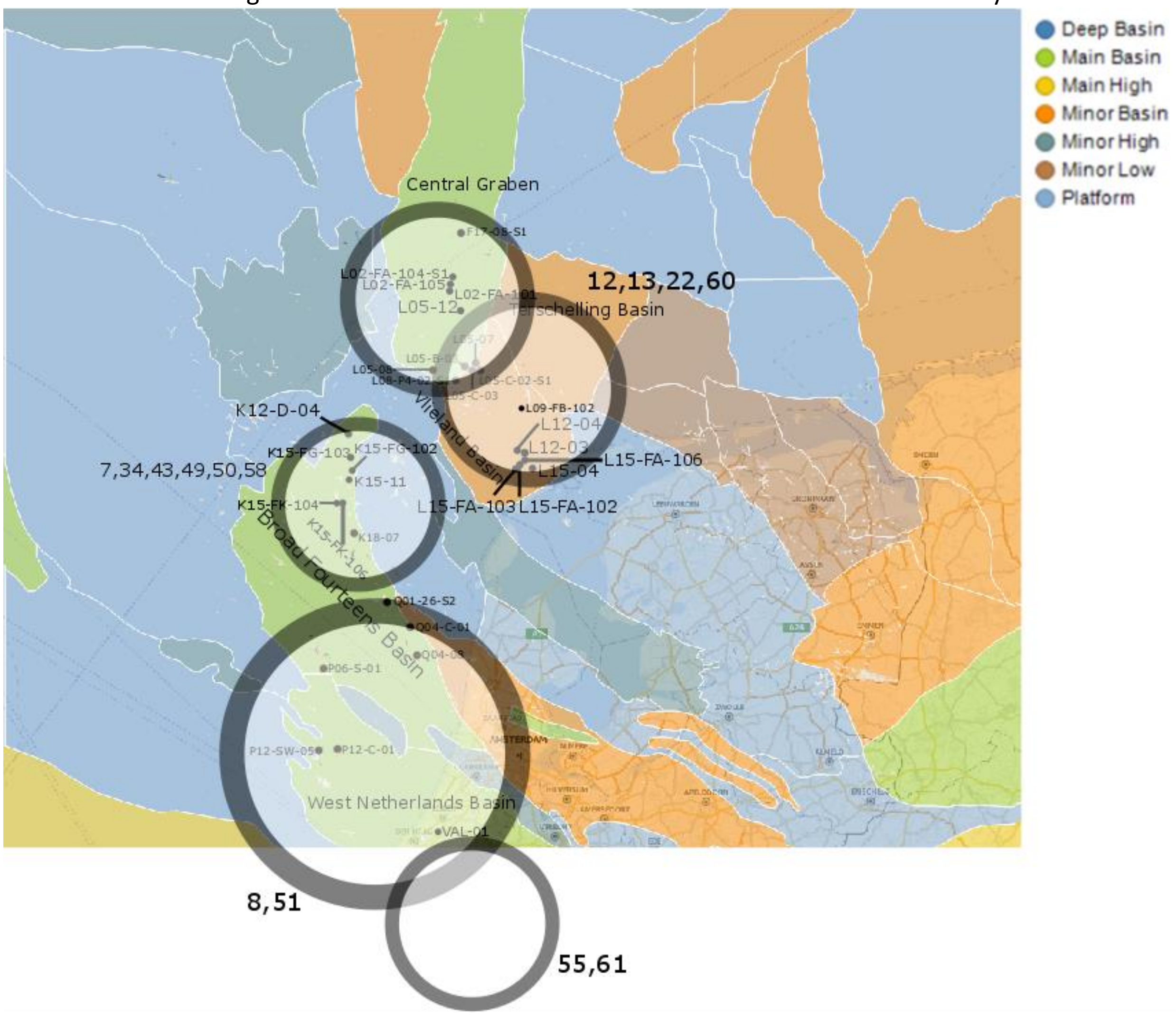

Figure 40 – The location of wells used for combined Excel analysis. The wells used for analysis have been labeled with their corresponding well name, these amount to 44. Confidential wells have been labeled with a single digit and assigned an approximate location, the range of which is indicated with opaque, black-rimmed circles. The names for the structural elements have been indicated. BLK-01 and NMD-03 fall outside the contours of the map.

For all three structural elements (fig. 41), the following T2Dcon pattern is recognized, leaving top N out of consideration: Small error for top CK - large top KN error - decreasing error until top UGT - large top LGT error - decreasing error until top RO (with a large error for the Main Basin and DCG).

From figures 41 and 42 it can be derived that the largest T2Dcon (Dz) errors are made in the Main Basin, due to Wintershall-license wells, for top KN and DC in specific. The largest DCG T2Dcon errors are obtained due to Wintershall-license wells, for top CK, KN and LGT (fig. 42 and 45).

From fig. 41 and 44, it is obvious that the largest Vlieland Basin errors occur in top KN (mainly due to ENGIE-license wells).

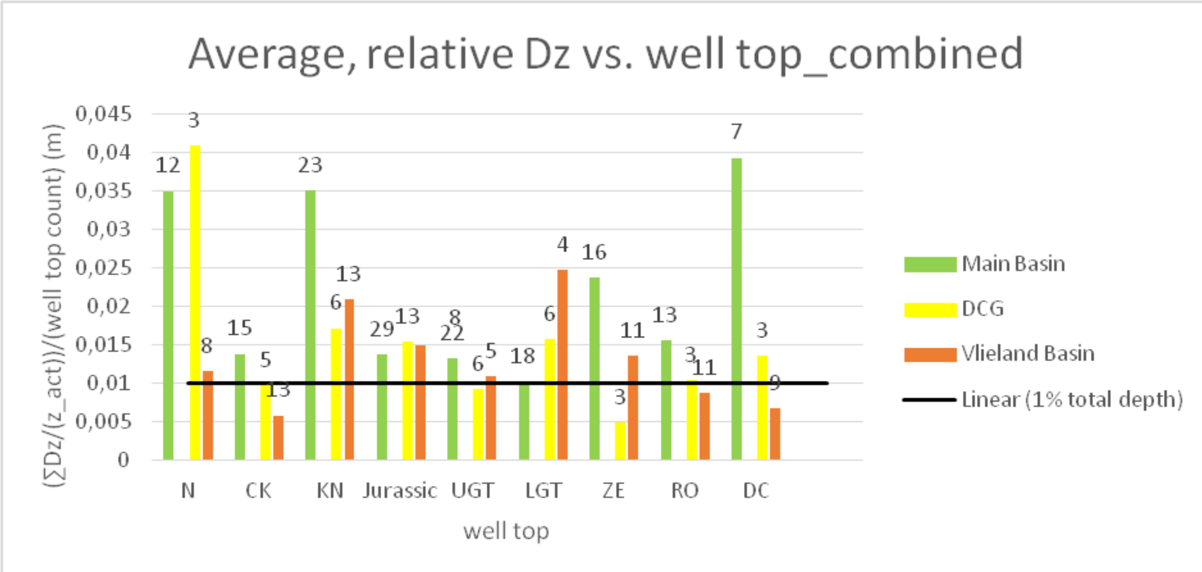

Figure 41 – Combined analysis of the average, relative Dz for all wells analyzed in the Main Basin, DCG and Vlieland Basin. Leaving top N out of consideration, top KN and top Jurassic yield errors for all three structural elements. The bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units.

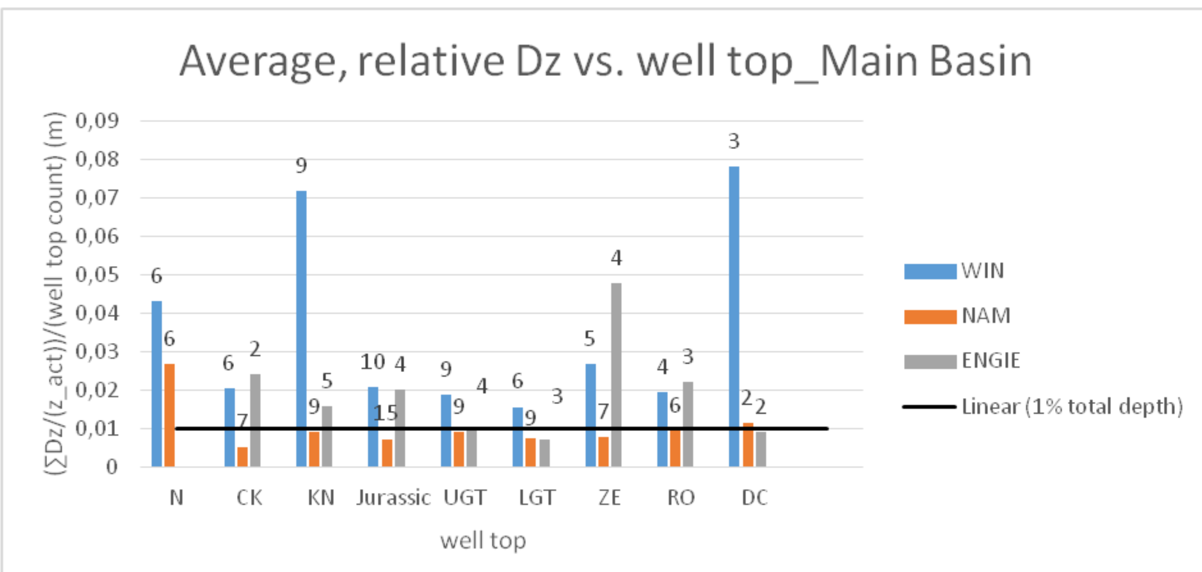

Figure 42 - Combined analysis of the average, relative Dz for all Main Basin wells for the three operators (see legend). The bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units. WIN=Wintershall.

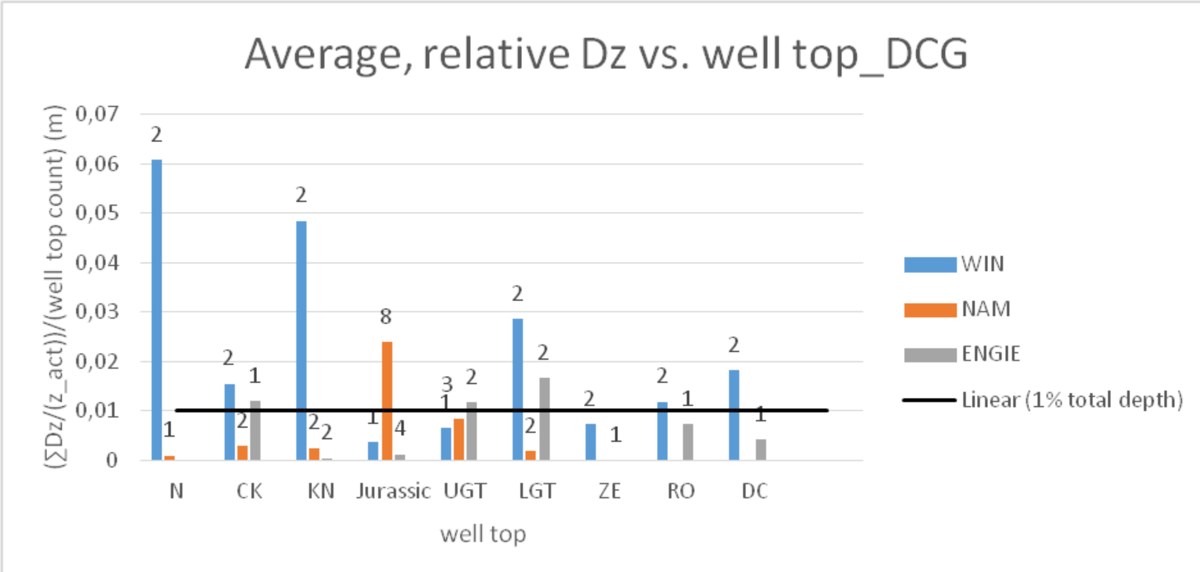

Figure 43 - Combined analysis of the average, relative Dz for all DCG wells for the three operators (see legend). The bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units. WIN=Wintershall.

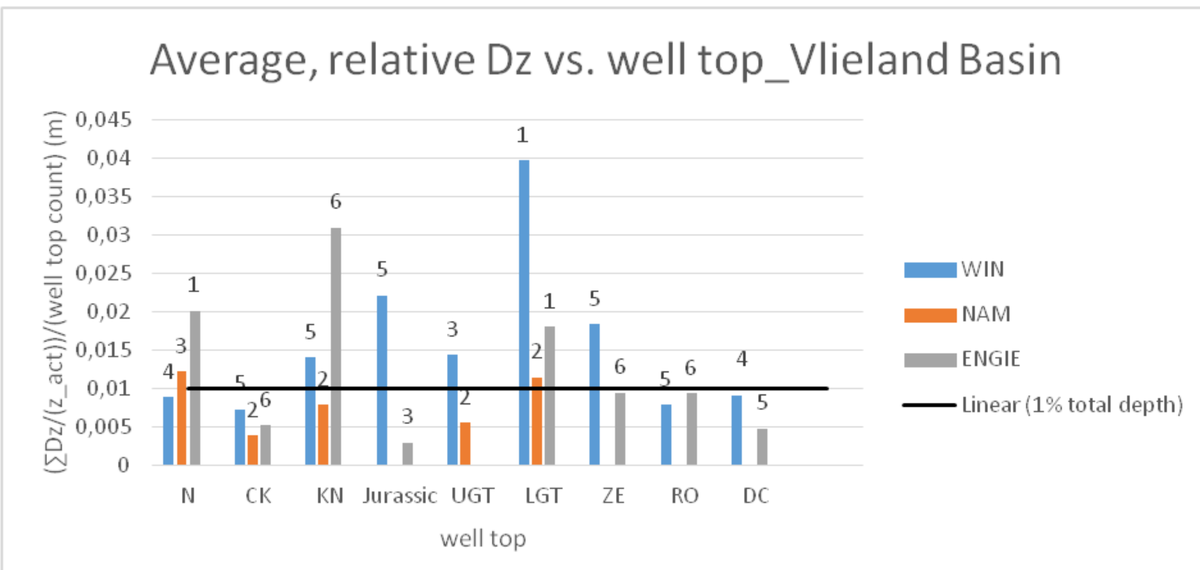

Figure 44 - Combined analysis of the average, relative Dz for all Vlieland Basin wells for the three operators (see legend). The bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units. WIN=Wintershall.

Average, relative dDz vs. well top analysis (fig. 45) gives results similar to figure 41. Generally, dDz T2Dcon errors are larger (for all three structural elements).

- For Wintershall B.V. and NAM, top RO T2Dcon error is smaller.
- For Wintershall B.V. and ENGIE, top RO and DC T2Dcon errors are slightly smaller.
- For Wintershall B.V. and NAM, top LGT errors are smaller.

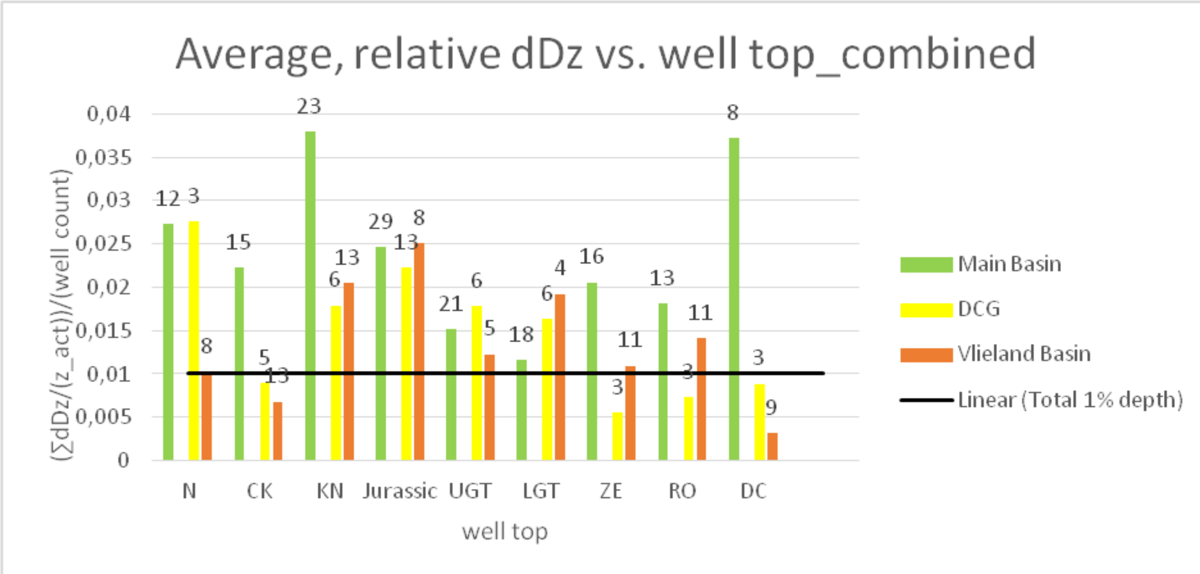

Figure 45 - Combined analysis of the average, relative dDz for all wells analyzed in the Main Basin, DCG and Vlieland Basin. Leaving top N out of consideration, top KN and top Jurassic yield errors for all three structural elements. The bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units.

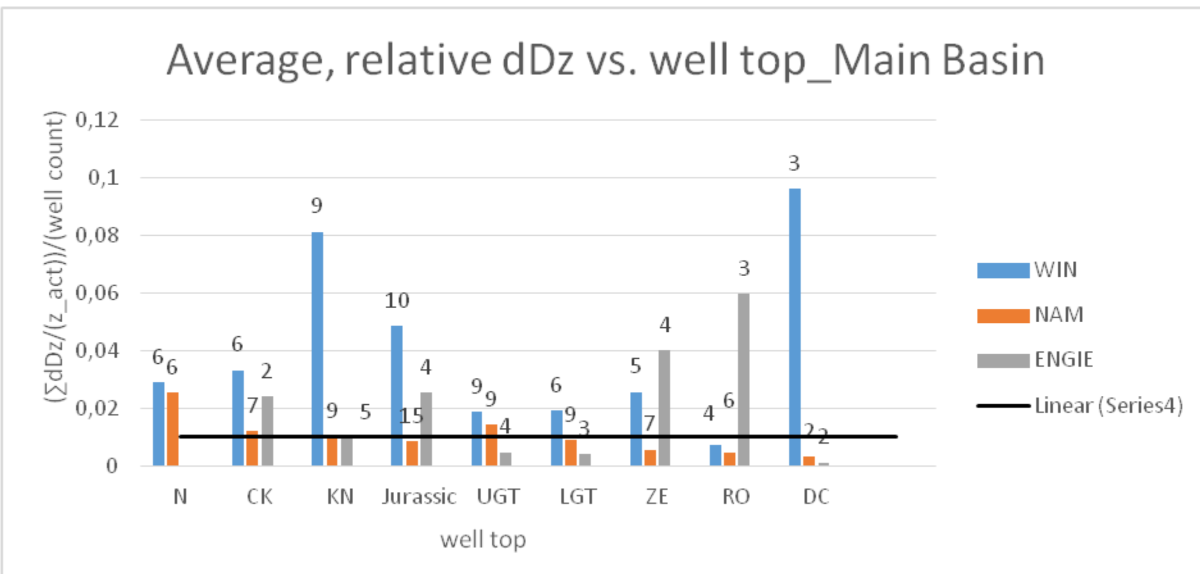

Figure 46 - Combined analysis of the average, relative dDz for all Main Basin wells for the three operators (see legend). The bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units. WIN=Wintershall.

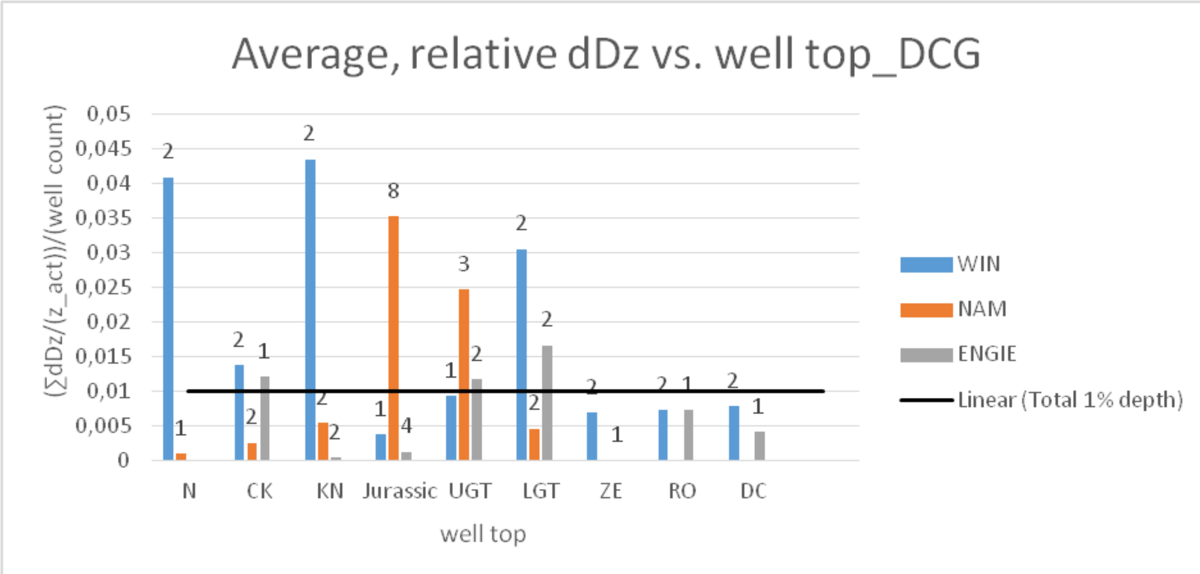

Figure 47 - Combined analysis of the average, relative dDz for all DCG wells for the three operators (see legend). The bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units. WIN=Wintershall.

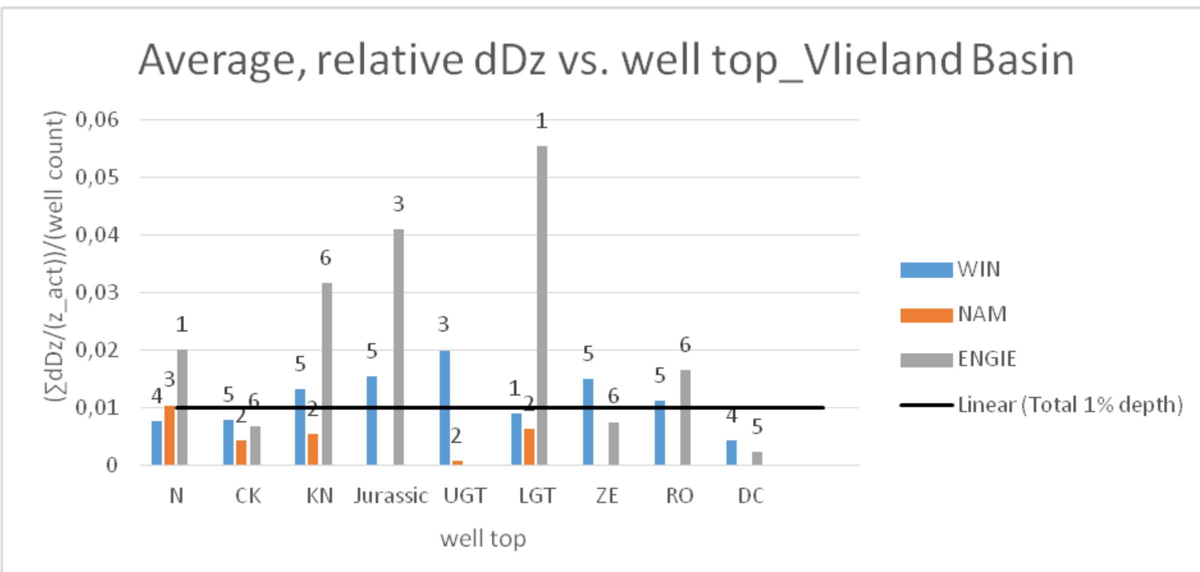

Figure 48 - Combined analysis of the average, relative dDz for all Vlieland Basin wells for the three operators (see legend). The bars are based on absolute values for T2Dcon errors. Numbers above bars represent the formation top prognosis count. See appendix 4 for a list of abbreviations of the stratigraphic units. WIN=Wintershall.

General Discussion

Figures 7, 18 and 30 (pp. 12, 22 and 32) indicate which areas (or specific wells) have the largest T2Dcon difficulties for the three operators Wintershall, ENGIE and NAM, respectively. Whenever T2Dcon errors of individual wells are discussed, reference is made to appendix 3.

Well D12-A-02 (location 1, fig. 7) is located in an area in which erosion (of Zechstein, Triassic and Jurassic sediments) has taken place until Mid and Early Cretaceous (Kombrink et al., 2012). D12-A-02 shows lower than normal porosity. Erosion and subsequent isostatic rebound of underlying sedimentary rocks may have lead to de-compaction of the buried rocks. Reduced compaction means that seismic velocities may have been estimated too high. Nearby, well 41 is drilled (location 3, fig. 18) where a salt-related origin for T2Dcon errors is considered. ZE floaters and anhydrite rafts exist in the area of well 41 and this may cause velocity pull-up effects, which cause negative values for T2Dcon errors.

Area 2 (of fig. 18) is thought to have been severly influenced by mainly halokinesis and tectonics, in general. The area straddles the Broad Fourteens Basin, strongly inverted in the Late Cretaceous, and the Central Offshore Platform. L10-27 yields large T2Dcon errors (fig. 60 and 65) that partly originate from distorted seismic imaging and partly from the presence of a salt dome. Seismic ray paths traveling close to the edge (or through) the salt have been used for horizon mapping. These horizons have often been mapped too high in depth, based on higher seismic velocities. Actual well tops thus come in deep to prognosis and T2Dcon errors are negative.

Near that section, area 3 (in fig. 30) is located, coinciding with part of the K15-block; an area notoriously known for T2Dcon difficulties related to halokinesis. Although many K15 wells have T2Dcon errors within the acceptable range (+/- 20m), K15-FG-103 had top LGT mispredicted, shallow to prognosis. The region of K15-FG-103 is located below a salt dome and is tectonically very complex. This error may possibly also be due to using salt-affected ray paths, mapping overlying horizons shallow to prognosis, based on higher seismic velocities. This is, however, speculation.

Late-Cretaceous inversion is thought to cause T2Dcon difficulties for the Broad Fourteens Basin in general (and for the West Netherlands Basin as well). From figure 26, it is evident that structural geologic complexities cause T2Dcon errors for K18-07 (area 3, fig. 7), drilled in an area close by the previously discussed wells in the BFB in which halokinesis is of lesser influence on T2Dcon errors.

Halokinesis is a likely source for T2Dcon errors for the area straddling the boundary between the Vlieland and Terschelling Basin (area 6, fig. 7). From figure 17 (for well L06-07), it is clear that halokinesis causes faulting and thus affects the velocity of overlying layers. Although both the Vlieland and Terschelling basins have not been subjected to major inversion, from fig. 54 and 59, it is apparent that significant T2Dcon errors exist in top KN and top Jurassic. It is thought that T2Dcon errors for wells in these basins mainly originate from the effect of halokineses, although this cannot clearly be demonstrated.

The southern part of the Vlieland Basin appears distinct from area 6 of fig. 7. Area 1 of fig. 18 is located in that section, in which well L12-03 is drilled. The Vlieland Basin is described as a Late Jurassic and Early Cretaceous depocenter that experienced a lot of faulting (Kombrink et al., 2012). From fig. 49, it is apparent that mainly the Zechstein and Upper Rotliegend Groups have been affected by faulting. Overlying layers, i.e. Rijnland, have also been faulted, but to a minor extent. It is obvious that halokinesis has not played a role in faulting.

Nearby these areas, area 5 of fig. 7 is located, comprising two wells (L05-08 and L05-B-03) which are located in the Dutch Central Graben (DCG). The DCG experienced extensional faulting during the Late Jurassic and was strongly inverted during the Late Cretaceous and Paleogene. The formation of salt-diapirs occurred simultaneously with faulting. Most T2Dcon errors for both L05-08 and L05-B-03 are shallow to prognosis. This means that the effect of compaction has had a major effect on the lithologies and hence in T2Dcon. Most probably, T2Dcon errors in the southern part of the DCG are due to structural geological complexities (i.e. faulting), or halokinesis.

Area 2 of fig. 7 is located in the Cleaver Bank High. From positive, relative Dz T2Dcon errors (see fig. 51), possibly de-compaction-related problems exist for wells in this part of the Cleaver Bank High. Inversion since the Permian in the area (Quirk, 1993) may explain negative, relative Dz for wells in the Cleaver Bank High (see fig. 51).

Area 1 (fig. 30) comprises well LUT-06. For top Jurassic, the T2Dcon error is shallow to prognosis, implying that higher velocities due to greater compaction have not played a role in the misprediction. The existence of areas with low velocity layers may be partly due to erosion, postdating the major inversion event, and associated decompaction.

LUT-06 is located in the CNB, which has a complicated geological history. Faulting and subsequent inversion have taken place. The effect of compaction, providing higher-than expected velocities, appears to be a main problem for the De Lutte area. The oldest strata (of the Limburg Group) in that area were deformed and tilted eastwards during the Asturian and Hercynian tectonic phases. Later inversion created a complex fault pattern at Base Altena level and affected the entire post Triassic section up to the Tertiary (fig. 38). For LUT-06, T2Dcon errors for the stratigraphically deepest layers may be due to inversion.

Figures 71 and 76 show that T2Dcon errors for the West Netherlands basin (area 2, fig. 30) may also be inversion-related (because T2Dcon errors are often deep to prognosis) (see also Kombrink et al., 2012). Furthermore, these errors may be related to faulting in general (fig. 39).

These observations appear analogue to the area in the DCG of fig. 30. From fig. 70 and 75, it is clear that layers (at least up to top Jurassic) of DCG wells have been affected by a similar phenomenon (because top Jurassic is mispredicted deep to prognosis). Possibly, post-Jurassic (Cretaceous) erosion had more limited effect than expected, and the layers overlying the Jurassic remained compacted. Consequently, the velocities are higher than for sections in which the Jurassic has been eroded away to a larger extent. Alternatively, T2Dcon errors for the DCG may be related to halokinesis (Kombrink et al., 2012).

This is different from what is observed for the southern part of the DCG (area 5, fig. 7), discussed earlier. Well F17-08-S1 (location 4, fig. 7) is located in the center of the DCG. T2Dcon errors are mostly deep to prognosis, which implies that the effect of larger-than-expected compaction, masqueraded by inversion could have provided T2Dcon difficulties. Based on these observations, it may be expected that rocks in the center of the DCG have experienced less erosion and remained compacted to a greater degree, relative to rocks at the edge of the DCG which have smaller thicknesses and hence, record less compaction. Furthermore, the Jurassic has inconsistent lithology. Therefore, velocities are difficult to estimate.

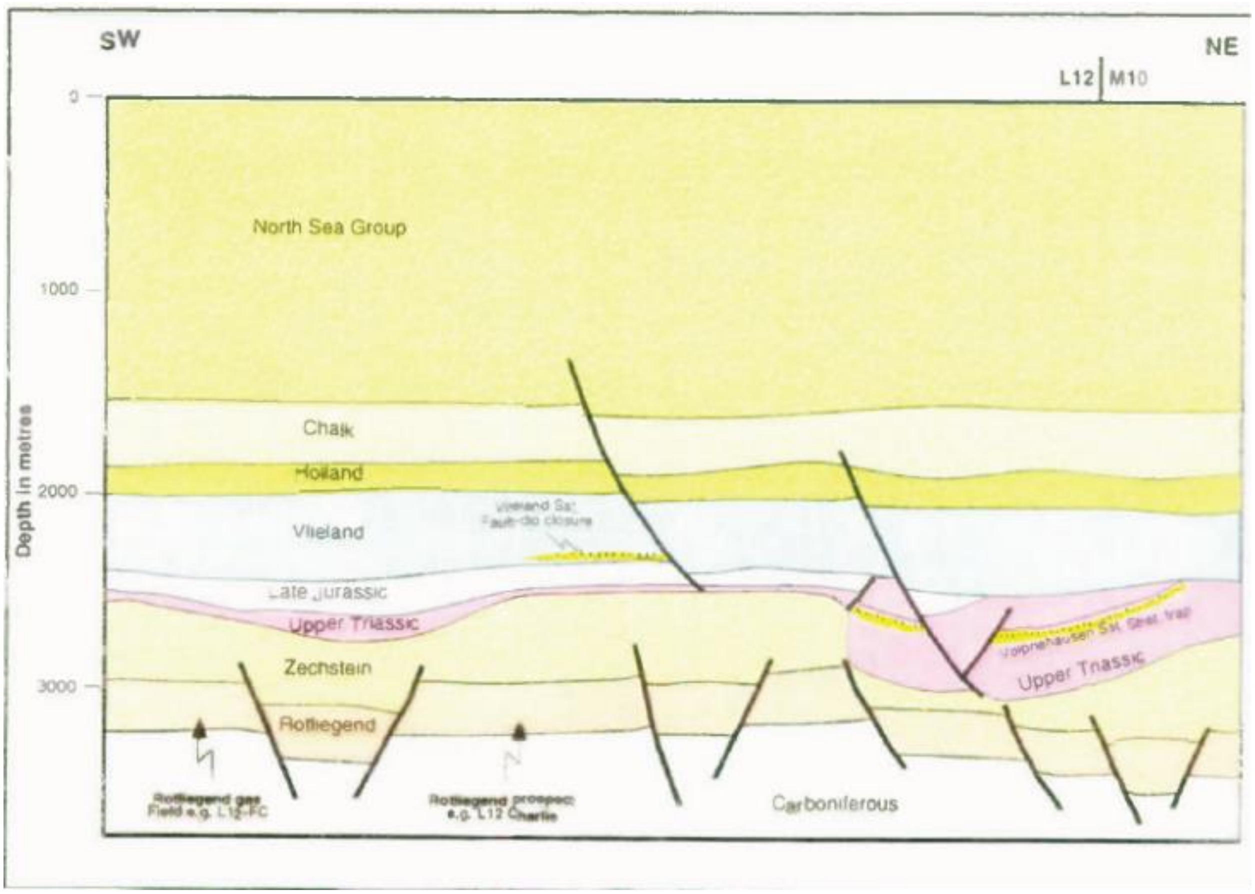

Figure 49 – Cross-section through part of the Vlieland Basin (exact location indicated on fig. 18). Mainly basement rocks have been affected by faulting. Overlying layers are faulted to a lesser extent.

Conclusions

- The main basins (Broad Fourteens Basin, West Netherlands Basin and Dutch Central Graben) often have large T2Dcon errors for all three operators. The minor (Vlieland and Terschelling Basin) often have largest T2Dcon errors for Wintershall (based on max. 9 wells, see e.g. figures 11 and 12). The platforms (Central Offshore Platform, Cleaverbank Platform, Friesland Platform) often have large T2Dcon errors for ENGIE and NAM (based on max. 8 (see e.g. figures 22 and 23) and 10 (see e.g. figures 35 and 36) wells, for ENGIE and NAM, respectively). The DCG+CNB+LSB structural element combination has large T2Dcon errors for NAM (based on max. 14 wells, see e.g. figure 36 and 37).
- For Wintershall and ENGIE, top KN often yields T2Dcon errors, especially for the main basins (based on 9 and 5 wells, for Wintershall and ENGIE, respectively). Additionally for ENGIE, Top ZE and RO consistently yield T2Dcon errors for most structural elements (see figures 42, 43 and 44). For ENGIE, The Main Basin (mainly Broad Fourteens Basin) and Platform yield largest T2Dcon errors for the stratigraphically deepest well tops (ZE and RO).
- In general, for the three operators T2Dcon errors are strongly related to the effects of complex geology (tilted and faulted or inverted crust), compaction (in combination with inversion), diagenesis, halokinesis and the presence of salt in general. The lack of sonic and VSP's does not help, nor does the presence of dated wells which have been T2D converted with the aid of 2D

seismic (instead of 3D seismic) and seismic reflector mispicks (which in this analysis have been corrected for).

- For Wintershall, T2D conversion errors are furthermore related to: reduced well control due to wildcat-wells, few sonic and VSP data, deviated well paths, hardrock floaters in the Zechstein, incorrect velocity models.
- For ENGIE, T2Dcon errors are furthermore related to the presence of floaters and anhydrite rafts, Deep, thin layers do not resolve processing velocities; T2Dcon errors are however lower in thin layers). Wildcat wells cannot be compared to nearby wells, reducing well control. Finally, poor, distorted (and dated) seismic imaging cause T2Dcon errors.

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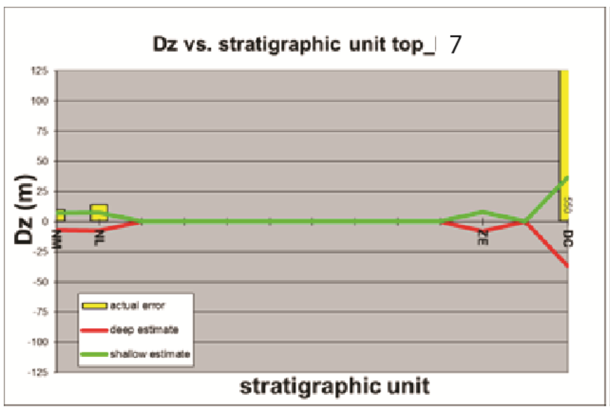
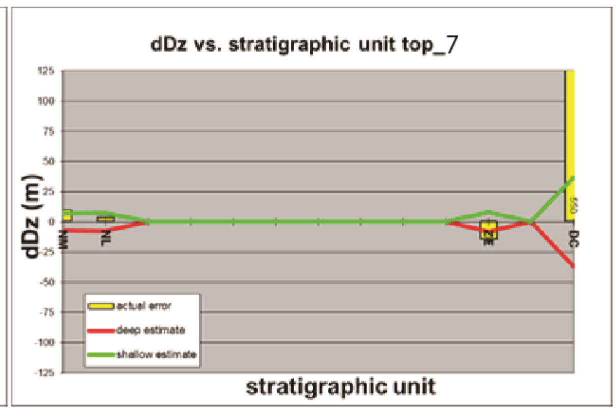
Appendices

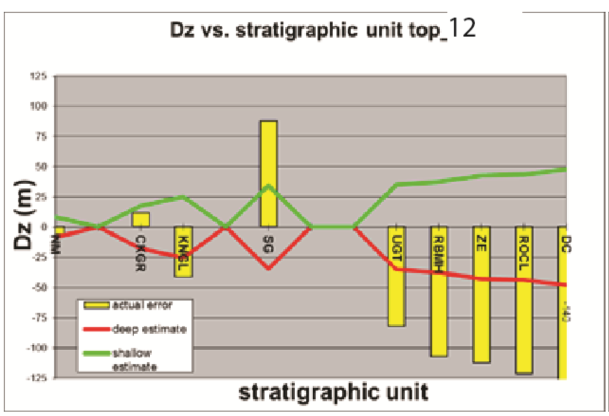
1. Bar diagrams of individual wells

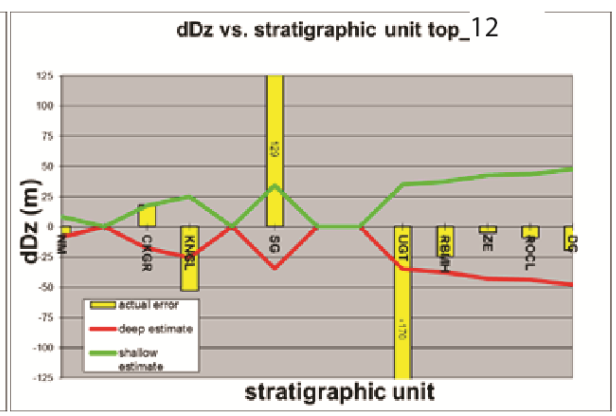
'Shallow estimate' (green curve) and 'Deep estimate' (red curve) are 1% of prognosed formation top depth. For Dz and dDz, positive values indicate that a formation top came in shallow to prognosis, negative values indicate that a formation top came in deep to prognosis. Numbers on the bars, for bars that fall outside the graph range, represent T2Dcon error values.

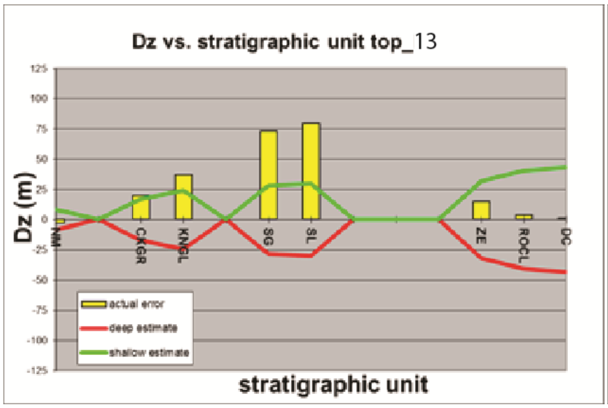
Wintershall

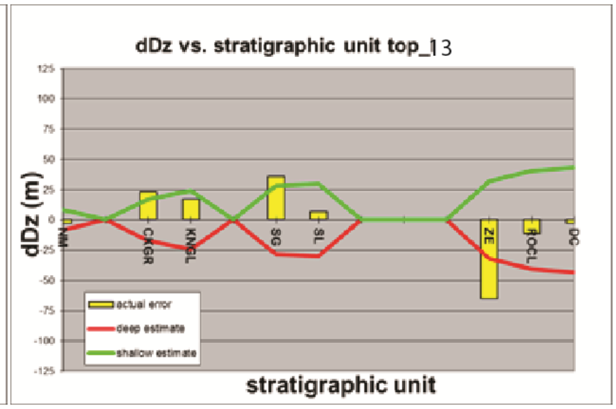


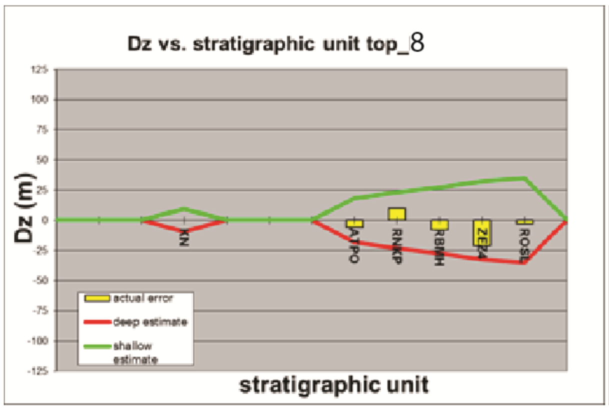


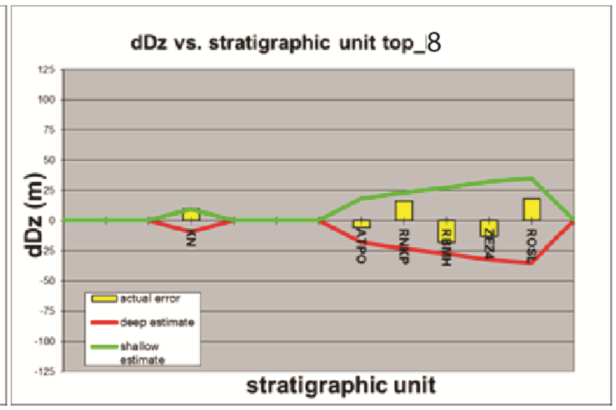


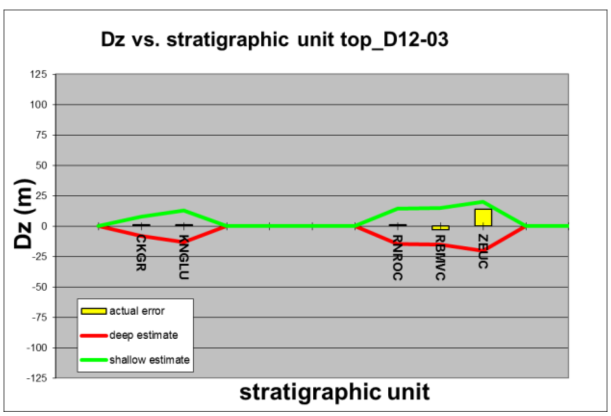


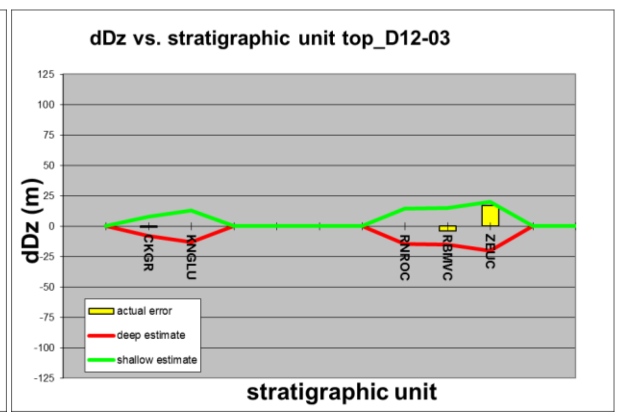

Dz vs. stratigraphic unit top_13
Dz (m)
NM
CKGR
KNGL
SG
SL
ZE
ROCL
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

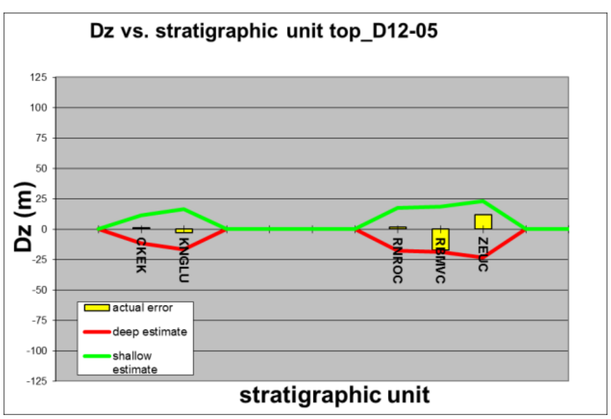

dDz vs. stratigraphic unit top_13
dDz (m)
NM
CKGR
KNGL
SG
SL
ZE
ROCL
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

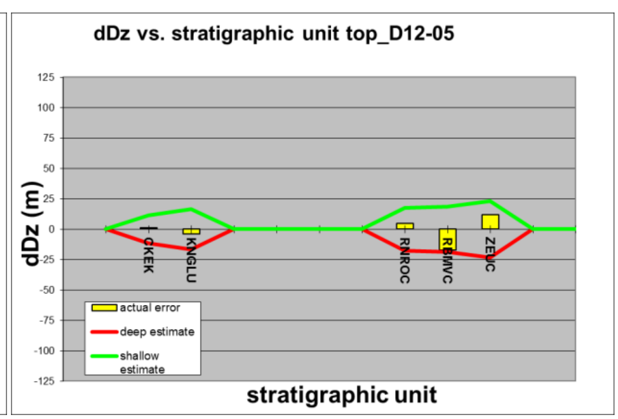

Dz vs. stratigraphic unit top_8
Dz (m)
KN
ATPO
RNKP
RBMH
ZEZ4
ROSL
actual error
deep estimate
shallow estimate
stratigraphic unit

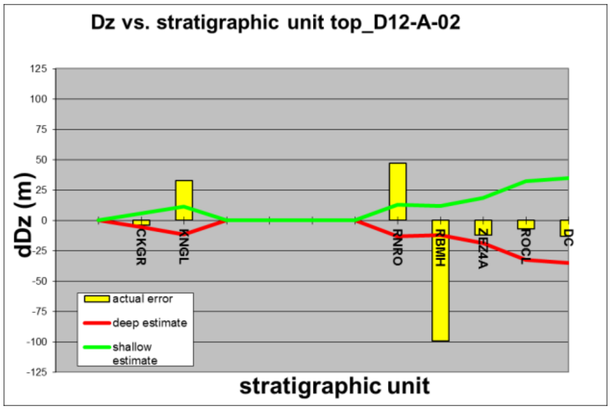

dDz vs. stratigraphic unit top_8
dDz (m)
KN
ATPO
RNKP
RBMH
ZEZ4
ROSL
actual error
deep estimate
shallow estimate
stratigraphic unit

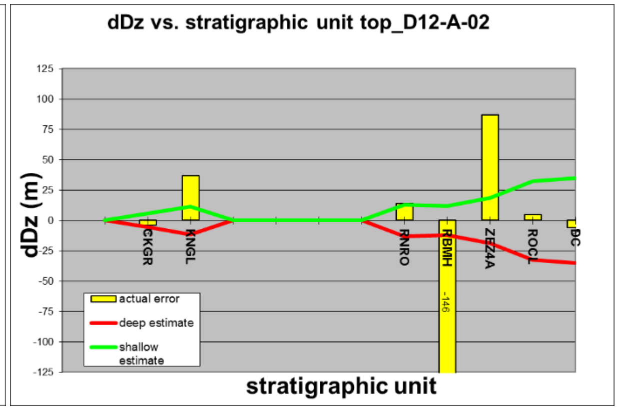

Dz vs. stratigraphic unit top_D12-03
Dz (m)
CKGR
KNGLU
RNROC
RBMVC
ZEUC
actual error
deep estimate
shallow estimate
stratigraphic unit

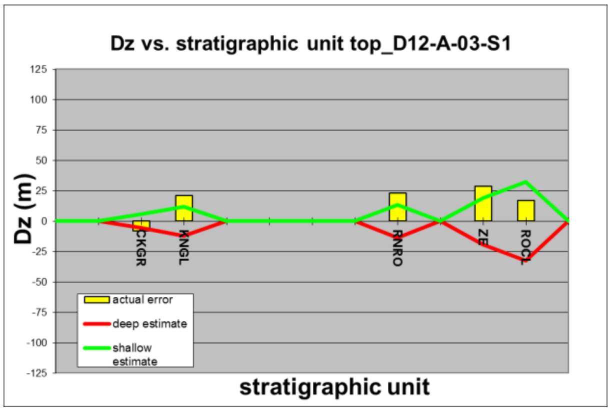

dDz vs. stratigraphic unit top_D12-03
dDz (m)
CKGR
KNGLU
RNROC
RBMVC
ZEUC
actual error
deep estimate
shallow estimate
stratigraphic unit

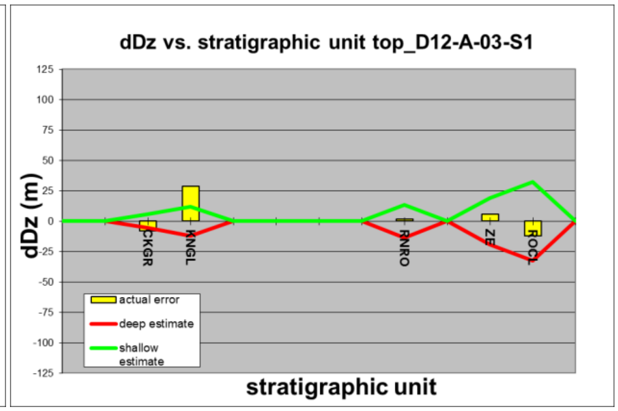

Dz vs. stratigraphic unit top_D12-05
Dz (m)
CKEK
KNGLU
RNROC
RBMVC
ZEUC
actual error
deep estimate
shallow estimate
stratigraphic unit

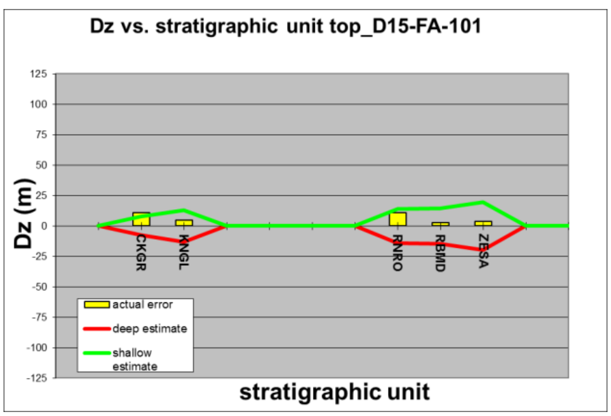

dDz vs. stratigraphic unit top_D12-05
dDz (m)
CKEK
KNGLU
RNROC
RBMVC
ZEUC
actual error
deep estimate
shallow estimate
stratigraphic unit

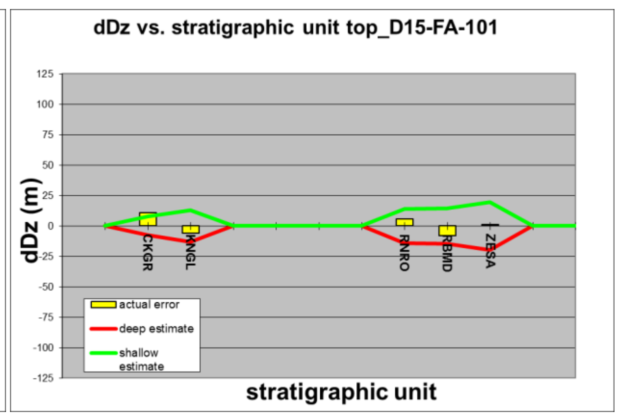

Dz vs. stratigraphic unit top_D12-A-02
125
100
75
50
25
0
-25
-50
-75
-100
-125
dDz (m)
CKGR
KNGL
RNRO
RBMH
ZEZ4A
ROCL
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

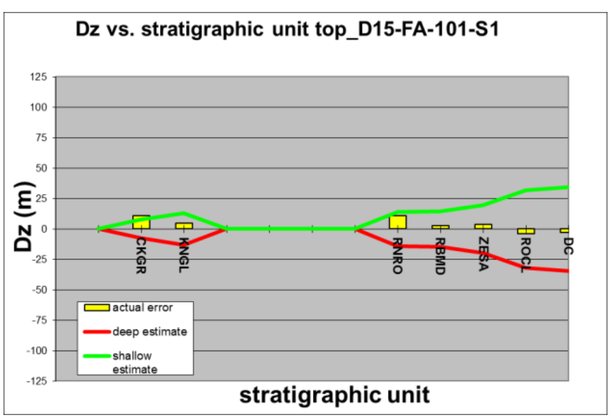

dDz vs. stratigraphic unit top_D12-A-02
125
100
75
50
25
0
-25
-50
-75
-100
-125
dDz (m)
CKGR
KNGL
RNRO
RBMH
-146
ZEZ4A
ROCL
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

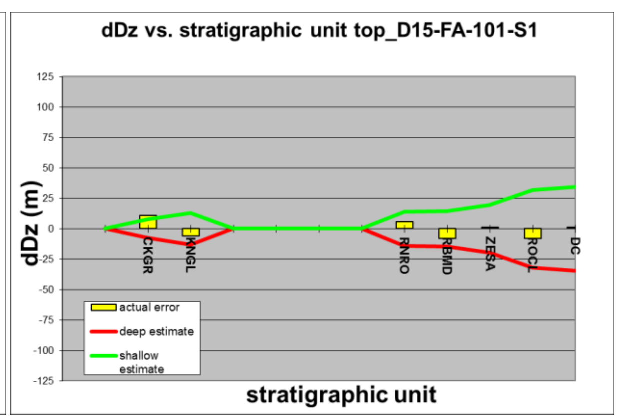

Dz vs. stratigraphic unit top_D12-A-03-S1
125
100
75
50
25
0
-25
-50
-75
-100
-125
Dz (m)
CKGR
KNGL
RNRO
ZE
ROCL
actual error
deep estimate
shallow estimate
stratigraphic unit

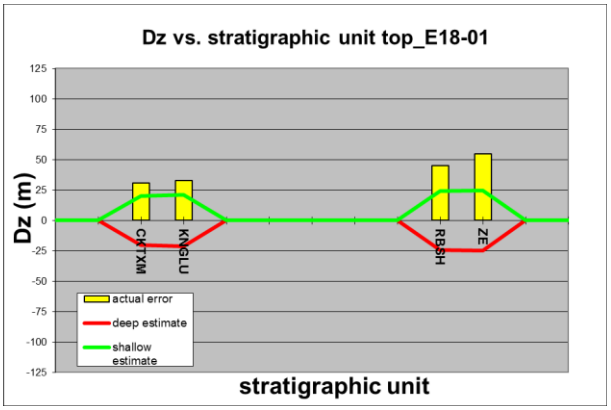

dDz vs. stratigraphic unit top_D12-A-03-S1
125
100
75
50
25
0
-25
-50
-75
-100
-125
dDz (m)
CKGR
KNGL
RNRO
ZE
ROCL
actual error
deep estimate
shallow estimate
stratigraphic unit

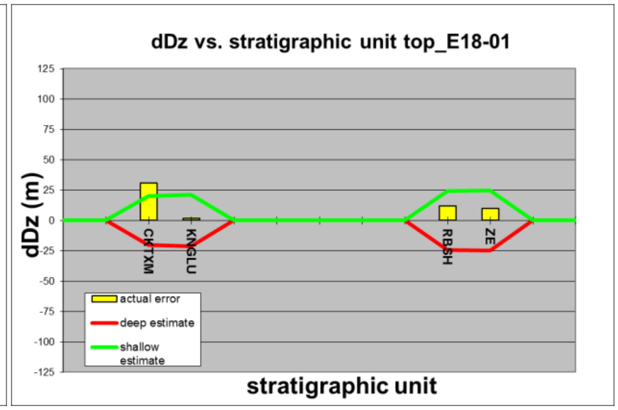

Dz vs. stratigraphic unit top_D15-FA-101
125
100
75
50
25
0
-25
-50
-75
-100
-125
Dz (m)
CKGR
KNGL
RNRO
RBMD
ZESA
actual error
deep estimate
shallow estimate
stratigraphic unit

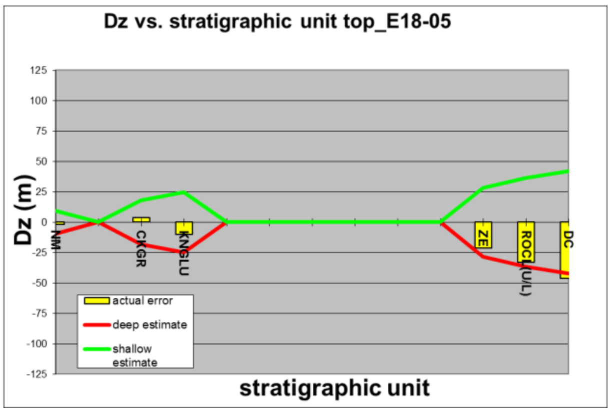

dDz vs. stratigraphic unit top_D15-FA-101
125
100
75
50
25
0
-25
-50
-75
-100
-125
dDz (m)
CKGR
KNGL
RNRO
RBMD
ZESA
actual error
deep estimate
shallow estimate
stratigraphic unit

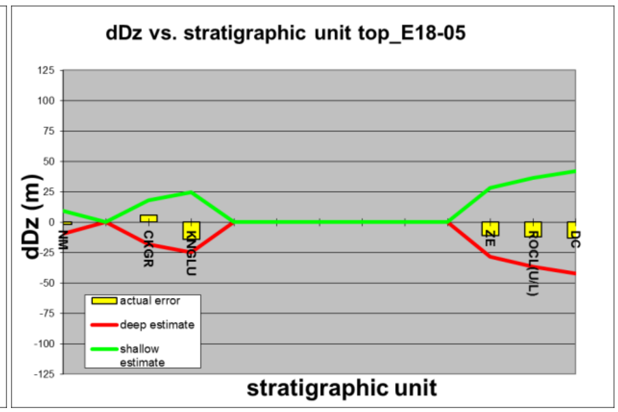

Dz vs. stratigraphic unit top_D15-FA-101-S1
125
100
75
50
25
0
-25
-50
-75
-100
-125
Dz (m)
CKGR
KNGL
RNRO
RBMD
ZESA
ROCL
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

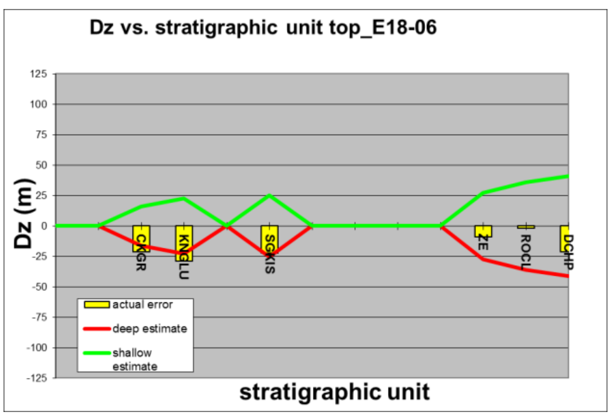

dDz vs. stratigraphic unit top_D15-FA-101-S1
125
100
75
50
25
0
-25
-50
-75
-100
-125
dDz (m)
CKGR
KNGL
RNRO
RBMD
ZESA
ROCL
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

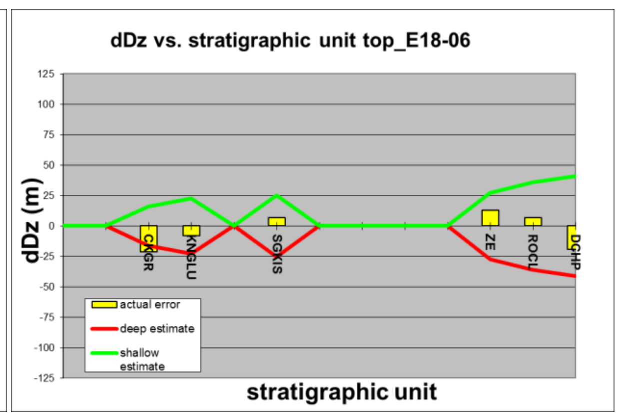

Dz vs. stratigraphic unit top_E18-01
Dz (m)
CKTXM
KNGLU
RBSH
ZE
actual error
deep estimate
shallow estimate
stratigraphic unit

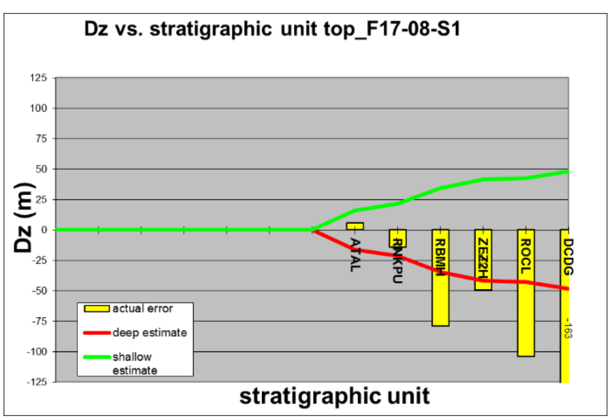

dDz vs. stratigraphic unit top_E18-01
dDz (m)
CKTXM
KNGLU
RBSH
ZE
actual error
deep estimate
shallow estimate
stratigraphic unit

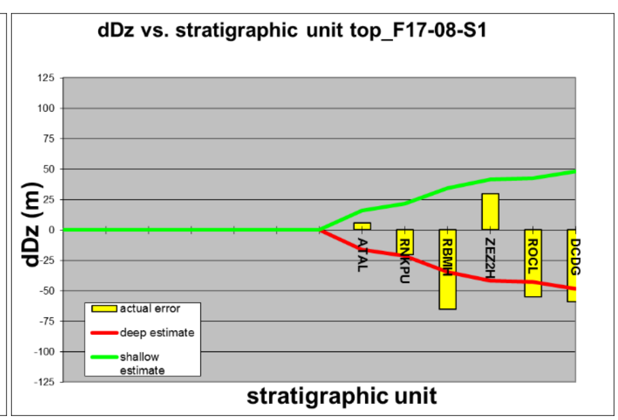

Dz vs. stratigraphic unit top_E18-05
Dz (m)
NM
CKGR
KNGLU
ZE
ROCL(U/L)
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

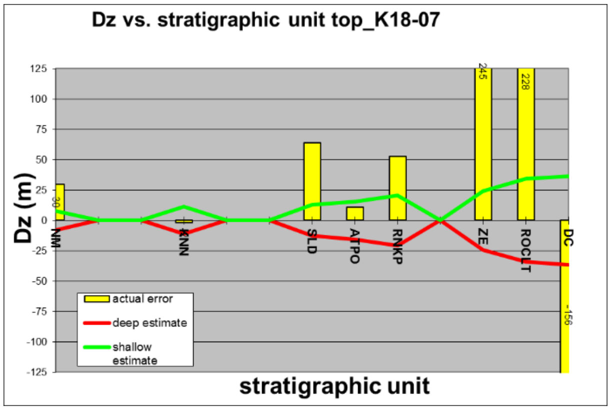

dDz vs. stratigraphic unit top_E18-05
dDz (m)
NM
CKGR
KNGLU
ZE
ROCL(U/L)
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

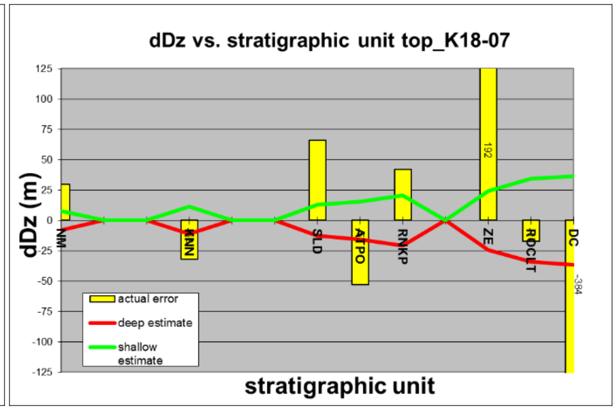

Dz vs. stratigraphic unit top_E18-06
Dz (m)
CKGR
KNGLU
SGKIS
ZE
ROCL
DGHP
actual error
deep estimate
shallow estimate
stratigraphic unit

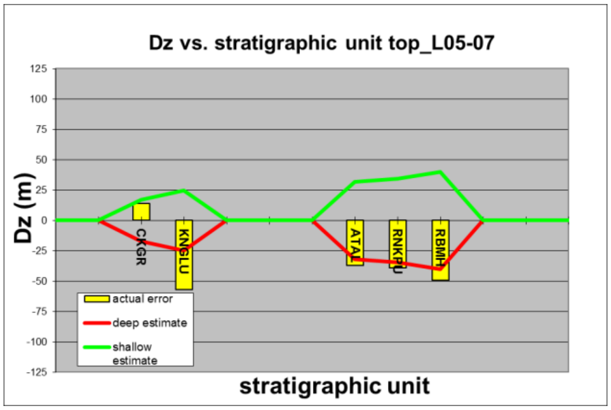

dDz vs. stratigraphic unit top_E18-06
dDz (m)
CKGR
KNGLU
SGKIS
ZE
ROCL
DGHP
actual error
deep estimate
shallow estimate
stratigraphic unit

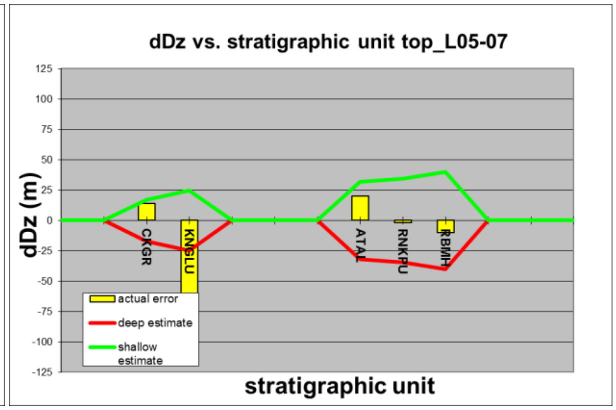

Dz vs. stratigraphic unit top_F17-08-S1
Dz (m)
ATAL
RNKPU
RBMM
ZEZ2H
ROCL
DCDG
-183
actual error
deep estimate
shallow estimate
stratigraphic unit

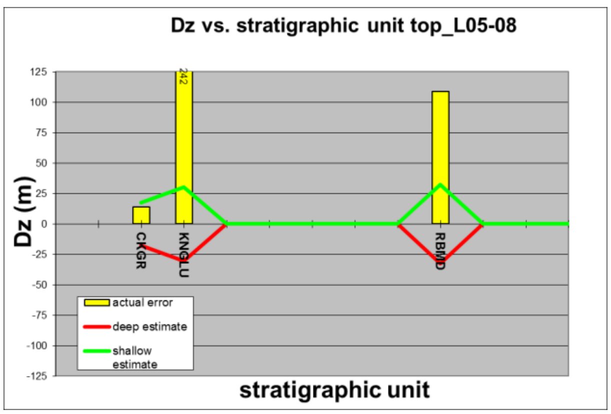

dDz vs. stratigraphic unit top_F17-08-S1
dDz (m)
ATAL
RNKPU
RBMM
ZEZ2H
ROCL
DCDG
actual error
deep estimate
shallow estimate
stratigraphic unit

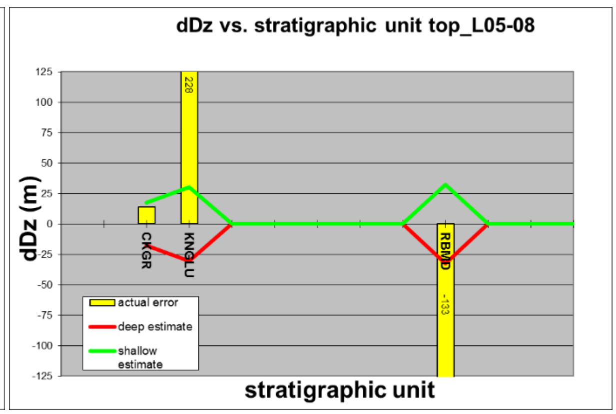

Dz vs. stratigraphic unit top_K18-07
Dz (m)
stratigraphic unit
NM
KNN
SLD
ATPO
RNKP
ZE
ROCLT
DC
30
245
228
-156
actual error
deep estimate
shallow estimate

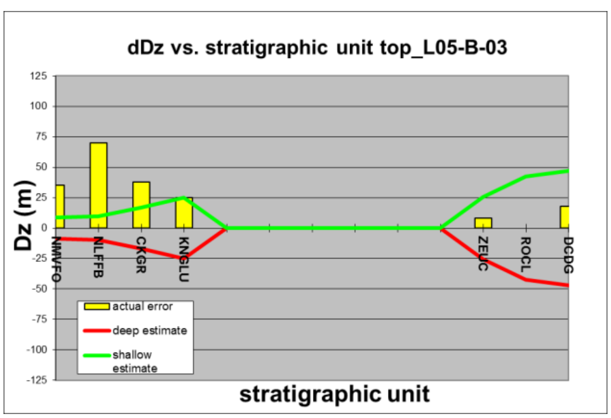

dDz vs. stratigraphic unit top_K18-07
dDz (m)
stratigraphic unit
NM
KNN
SLD
ATPO
RNKP
ZE
ROCLT
DC
192
-384
actual error
deep estimate
shallow estimate

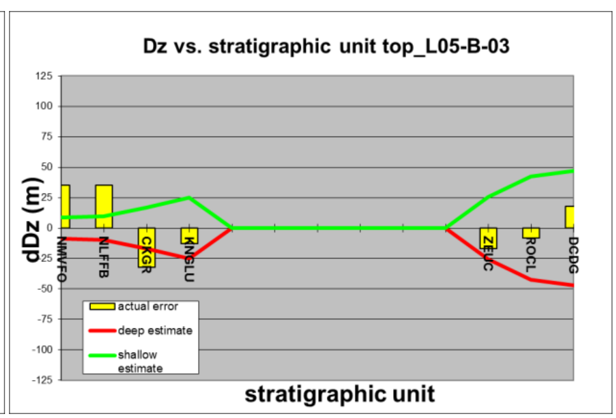

Dz vs. stratigraphic unit top_L05-07
Dz (m)
stratigraphic unit
CKGR
KNGLU
ATAL
RNKPU
RBMH
actual error
deep estimate
shallow estimate

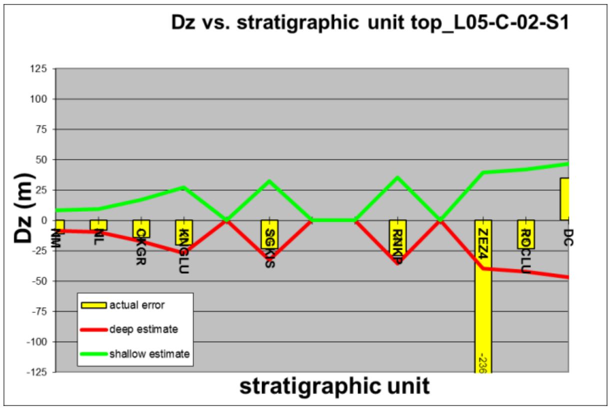

dDz vs. stratigraphic unit top_L05-07
dDz (m)
stratigraphic unit
CKGR
KNGLU
ATAL
RNKPU
RBMH
actual error
deep estimate
shallow estimate

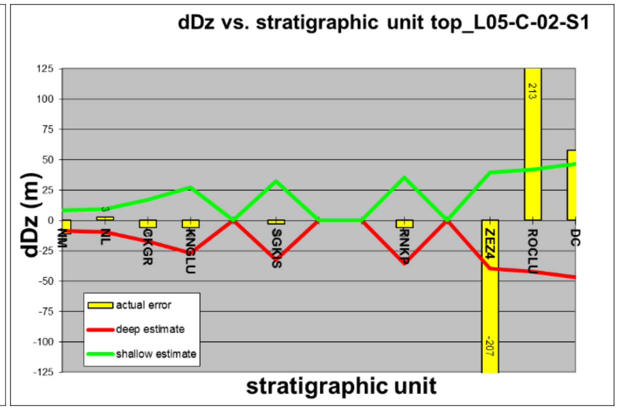

Dz vs. stratigraphic unit top_L05-08
Dz (m)
stratigraphic unit
CKGR
KNGLU
RBMD
242
actual error
deep estimate
shallow estimate

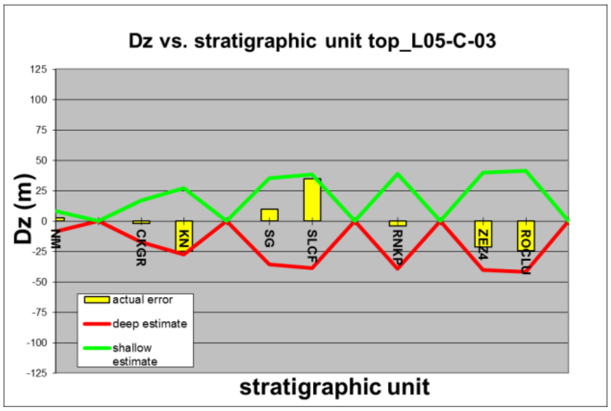

dDz vs. stratigraphic unit top_L05-08
dDz (m)
stratigraphic unit
CKGR
KNGLU
RBMD
228
-133
actual error
deep estimate
shallow estimate

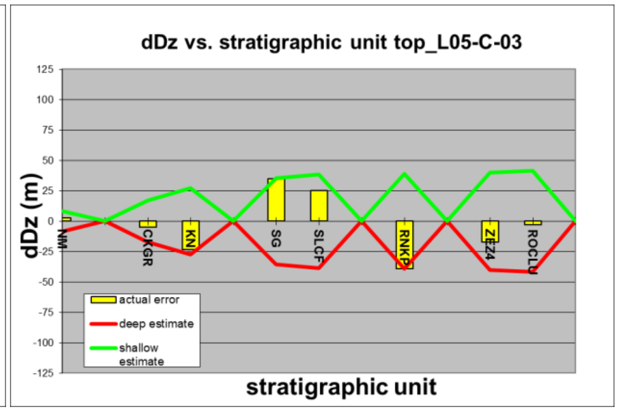

dDz vs. stratigraphic unit top_L05-B-03
Dz (m)
stratigraphic unit
NMVFO
NLFFB
CKGR
KNGLU
ZEUC
ROCL
DCDG
actual error
deep estimate
shallow estimate

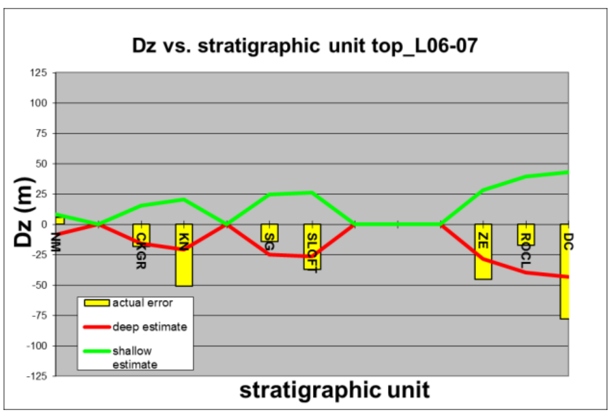

Dz vs. stratigraphic unit top_L05-B-03
dDz (m)
stratigraphic unit
NMVFO
NLFFB
CKGR
KNGLU
ZEUC
ROCL
DCDG
actual error
deep estimate
shallow estimate

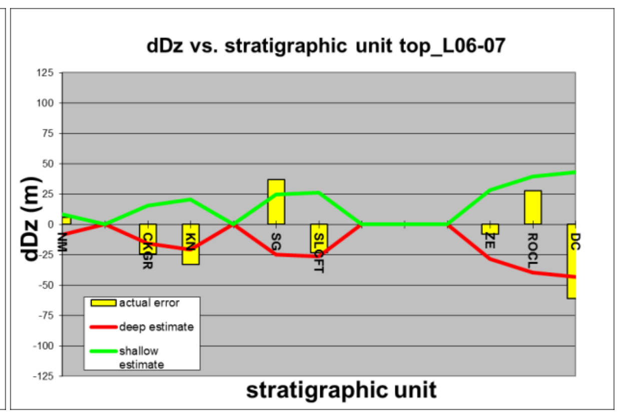

Dz vs. stratigraphic unit top_L05-C-02-S1
Dz (m)
stratigraphic unit
NM
NL
CKGR
KNGLU
SGKS
RNKP
ZEZ4
ROCLU
DC
-236
actual error
deep estimate
shallow estimate

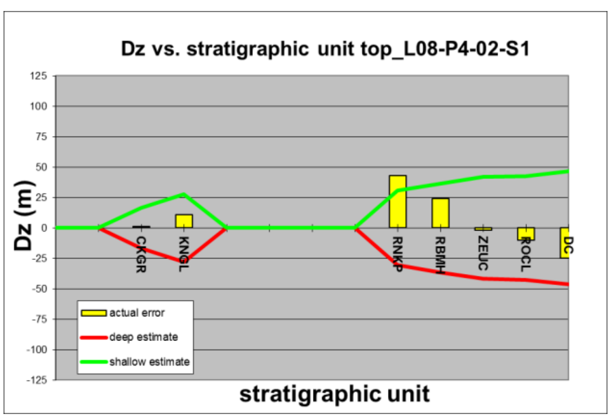

dDz vs. stratigraphic unit top_L05-C-02-S1
dDz (m)
stratigraphic unit
NM
NL
CKGR
KNGLU
SGKS
RNKP
ZEZ4
ROCLU
DC
213
-207
actual error
deep estimate
shallow estimate

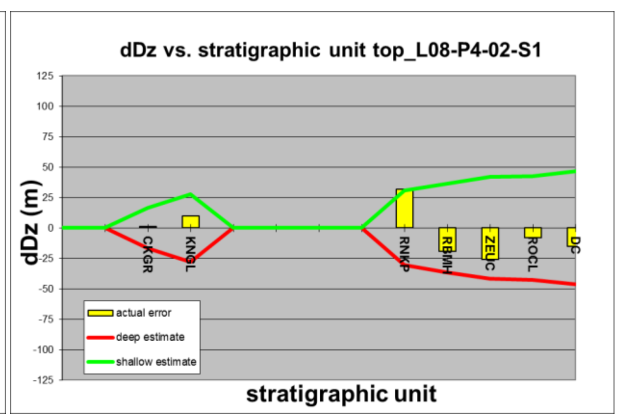

Dz vs. stratigraphic unit top_L05-C-03
Dz (m)
stratigraphic unit
NM
CKGR
KN
SG
SLCF
RNKP
ZEZ4
ROCLU
actual error
deep estimate
shallow estimate

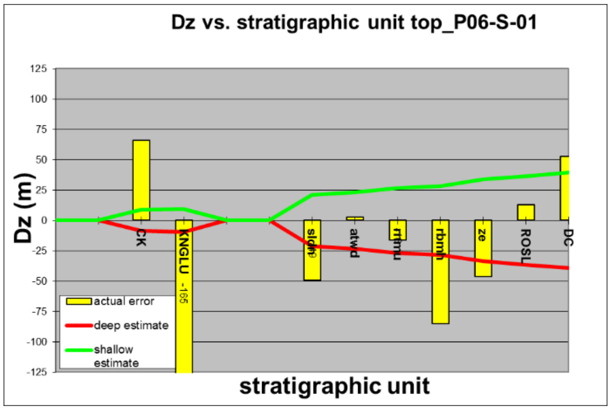

dDz vs. stratigraphic unit top_L05-C-03
dDz (m)
stratigraphic unit
NM
CKGR
KN
SG
SLCF
RNKP
ZEZ4
ROCLU
actual error
deep estimate
shallow estimate

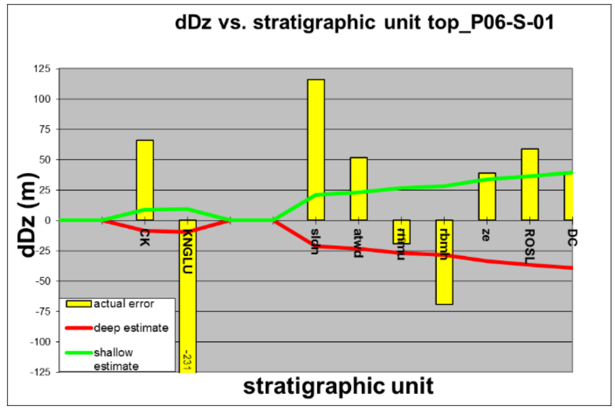

Dz vs. stratigraphic unit top_L06-07
Dz (m)
stratigraphic unit
NM
CKGR
KN
SG
SLCFT
ZE
ROCL
DC
actual error
deep estimate
shallow estimate

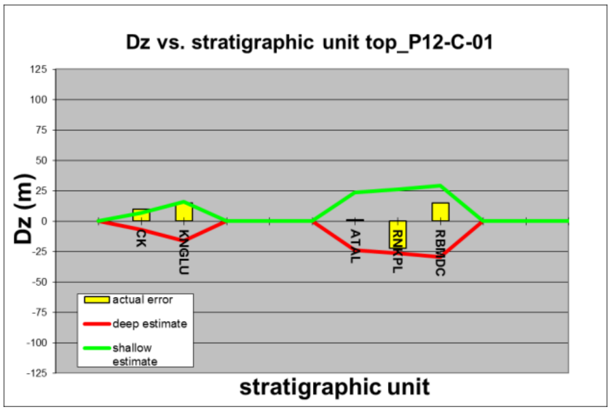

dDz vs. stratigraphic unit top_L06-07
dDz (m)
stratigraphic unit
NM
CKGR
KN
SG
SLCFT
ZE
ROCL
DC
actual error
deep estimate
shallow estimate

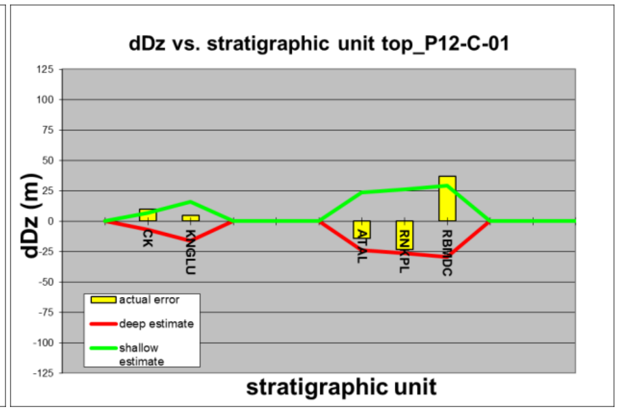

Dz vs. stratigraphic unit top_L08-P4-02-S1
Dz (m)
stratigraphic unit
CKGR
KNGL
RNKP
RBMH
ZEUC
ROCL
DC
actual error
deep estimate
shallow estimate

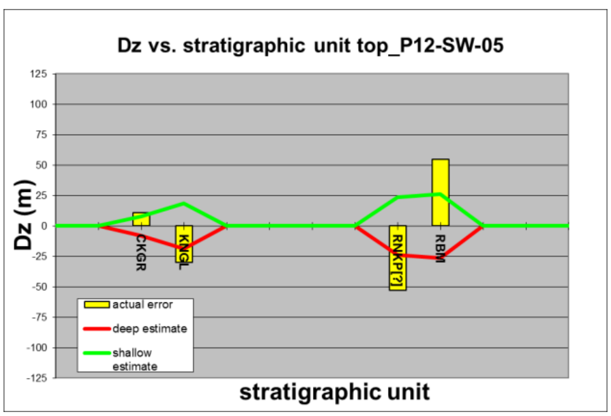

dDz vs. stratigraphic unit top_L08-P4-02-S1
dDz (m)
stratigraphic unit
CKGR
KNGL
RNKP
RBMH
ZEUC
ROCL
DC
actual error
deep estimate
shallow estimate

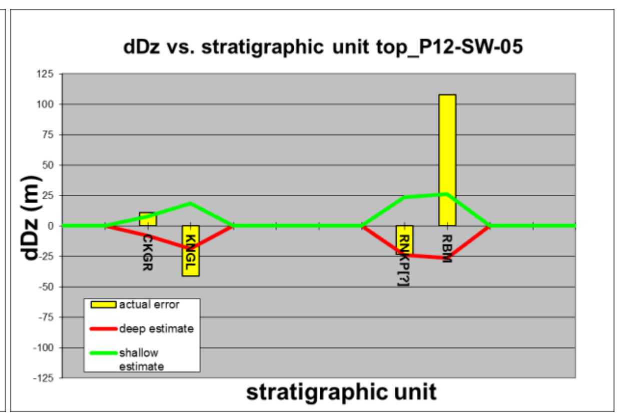

Dz vs. stratigraphic unit top_P06-S-01
125
100
75
50
25
0
-25
-50
-75
-100
-125
Dz (m)
CK
KNGLU
-165
sldn
atwd
rnmu
rbmh
ze
ROSL
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

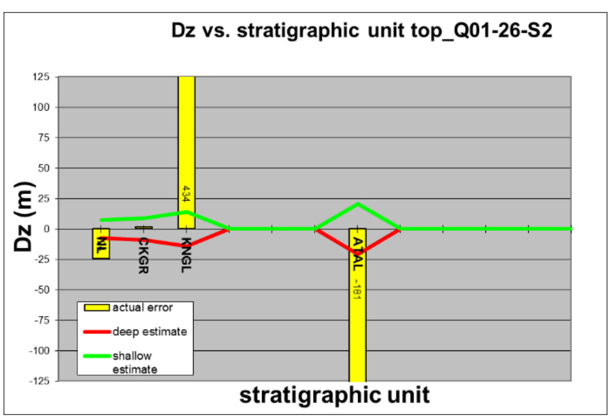

dDz vs. stratigraphic unit top_P06-S-01
125
100
75
50
25
0
-25
-50
-75
-100
-125
dDz (m)
CK
KNGLU
-231
sldn
atwd
rnmu
rbmh
ze
ROSL
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

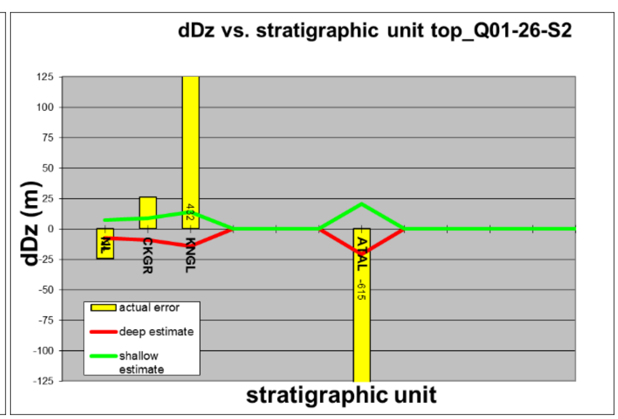

Dz vs. stratigraphic unit top_P12-C-01
125
100
75
50
25
0
-25
-50
-75
-100
-125
Dz (m)
CK
KNGLU
ATAL
RNKPL
RBMDC
actual error
deep estimate
shallow estimate
stratigraphic unit

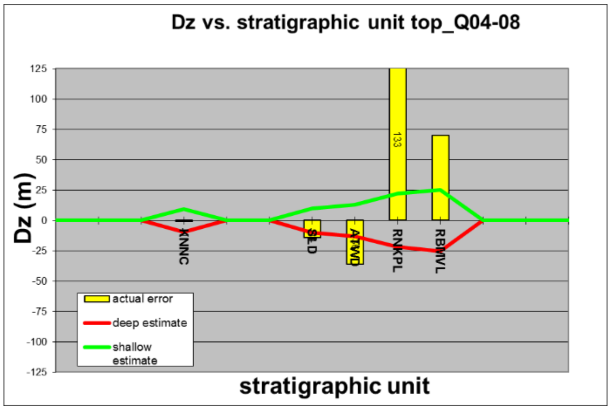

dDz vs. stratigraphic unit top_P12-C-01
125
100
75
50
25
0
-25
-50
-75
-100
-125
dDz (m)
CK
KNGLU
ATAL
RNKPL
RBMDC
actual error
deep estimate
shallow estimate
stratigraphic unit

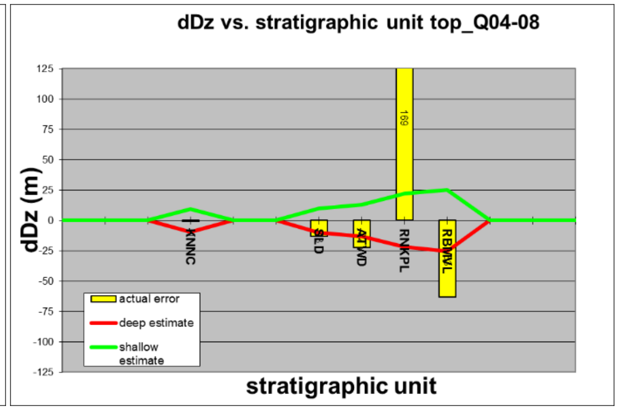

Dz vs. stratigraphic unit top_P12-SW-05
125
100
75
50
25
0
-25
-50
-75
-100
-125
Dz (m)
CKGR
KNGL
RNKP[?]
RBM
actual error
deep estimate
shallow estimate
stratigraphic unit

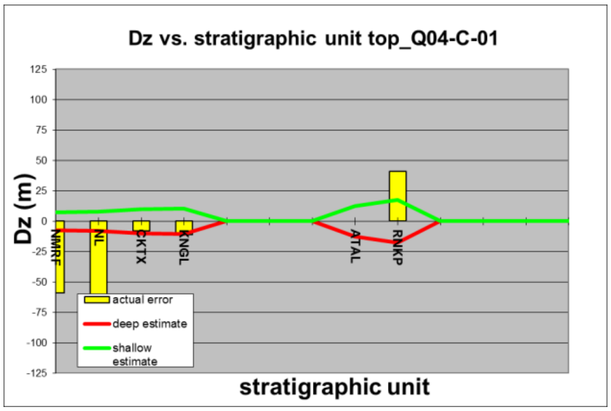

dDz vs. stratigraphic unit top_P12-SW-05
125
100
75
50
25
0
-25
-50
-75
-100
-125
dDz (m)
CKGR
KNGL
RNKP[?]
RBM
actual error
deep estimate
shallow estimate
stratigraphic unit

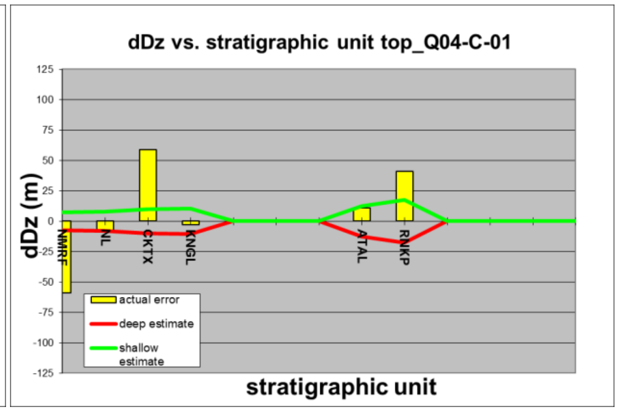

Dz vs. stratigraphic unit top_Q01-26-S2
125
100
75
50
25
0
-25
-50
-75
-100
-125
Dz (m)
NL
CKGR
KNGL
434
ATAL
-181
actual error
deep estimate
shallow estimate
stratigraphic unit


dDz vs. stratigraphic unit top_Q01-26-S2
125
100
75
50
25
0
-25
-50
-75
-100
-125
dDz (m)
NL
CKGR
KNGL
432
ATAL
-615
actual error
deep estimate
shallow estimate
stratigraphic unit

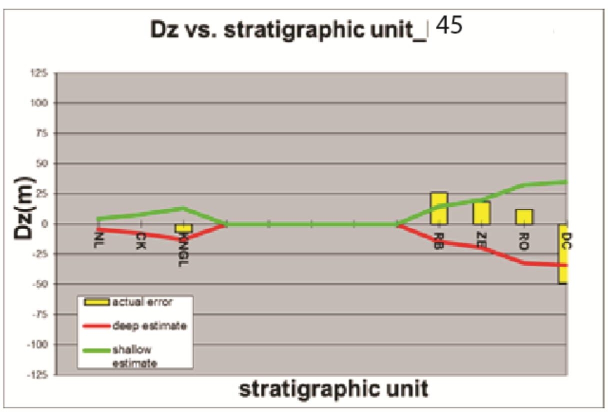

Dz vs. stratigraphic unit top_Q04-08
Dz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
133
KNNC
SLD
ATWD
RNKPL
RBMVL
actual error
deep estimate
shallow estimate
stratigraphic unit

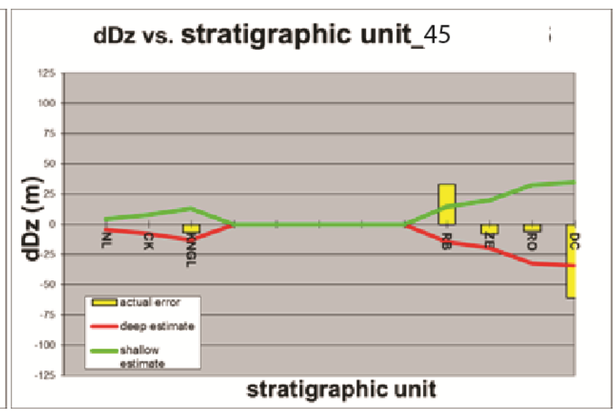

dDz vs. stratigraphic unit top_Q04-08
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
169
KNNC
SLD
ATWD
RNKPL
RBMVL
actual error
deep estimate
shallow estimate
stratigraphic unit

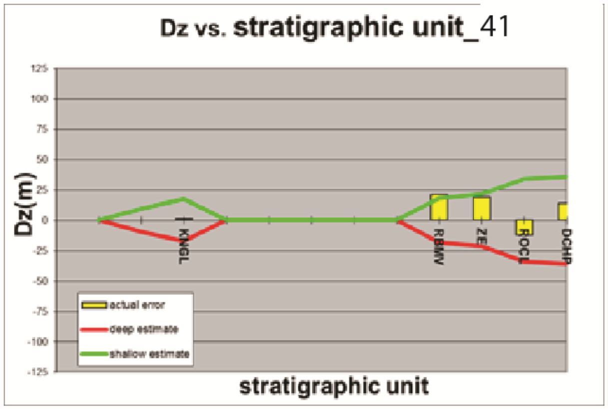

Dz vs. stratigraphic unit top_Q04-C-01
Dz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
NMRF
NL
CKTX
KNGL
ATAL
RNKP
actual error
deep estimate
shallow estimate
stratigraphic unit

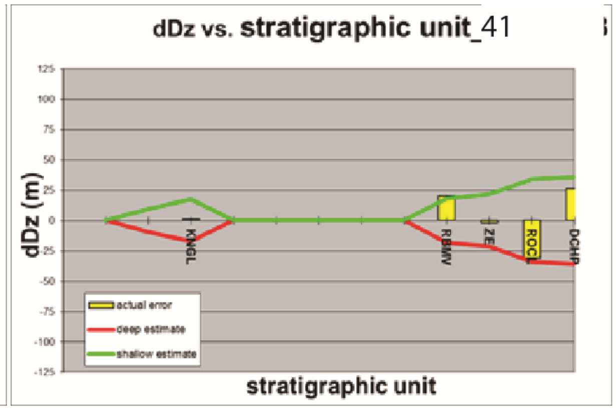

dDz vs. stratigraphic unit top_Q04-C-01
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
NMRF
NL
CKTX
KNGL
ATAL
RNKP
actual error
deep estimate
shallow estimate
stratigraphic unit

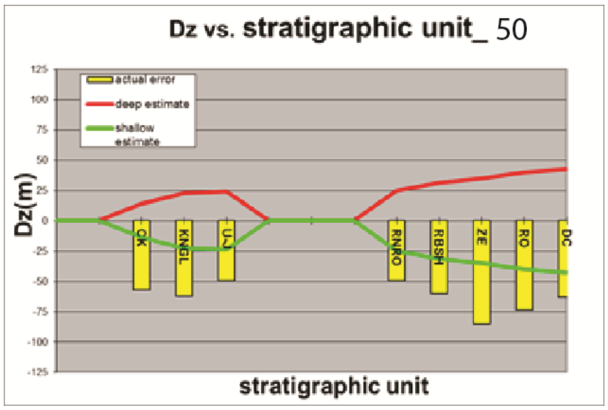
ENGIE

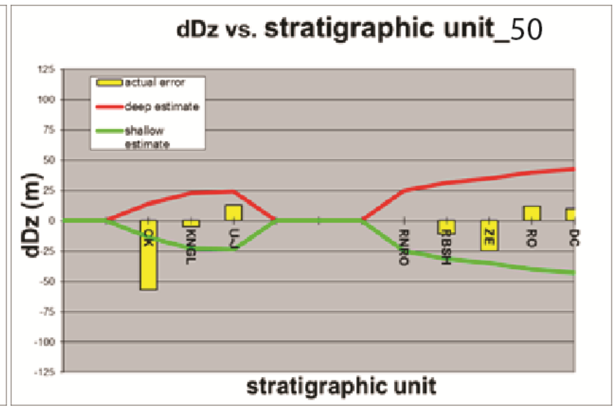

Dz vs. stratigraphic unit_ 45
Dz(m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
NL
CK
KNGL
RB
ZE
RO
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

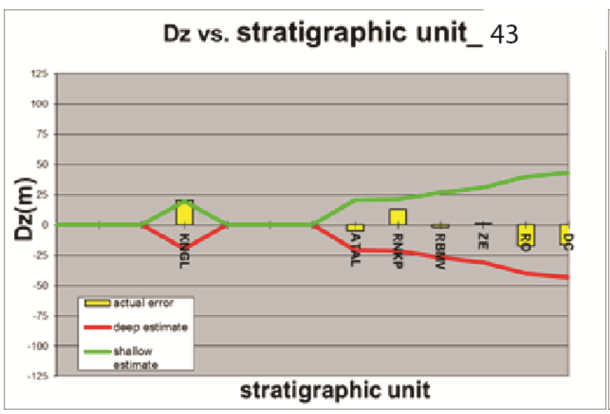

dDz vs. stratigraphic unit_45
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
NL
CK
KNGL
RB
ZE
RO
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

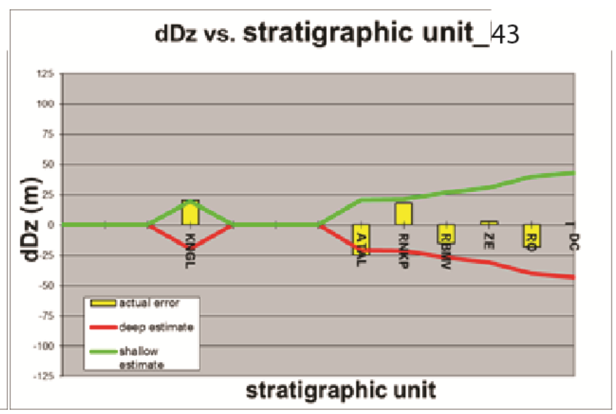

Dz vs. stratigraphic unit_41
Dz(m)
KNGL
RBMV
ZE
ROCL
DCHP
actual error
deep estimate
shallow estimate
stratigraphic unit

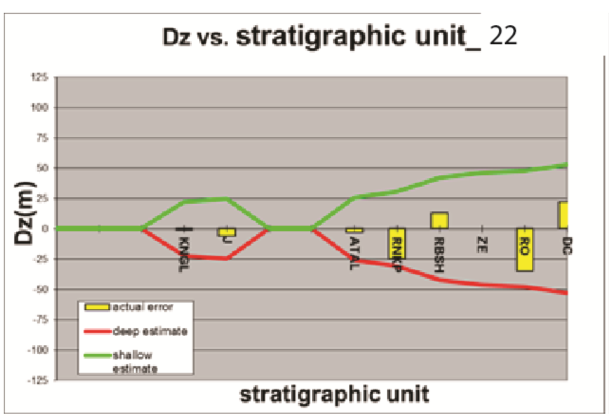

dDz vs. stratigraphic unit_41
dDz (m)
KNGL
RBMV
ZE
ROCL
DCHP
actual error
deep estimate
shallow estimate
stratigraphic unit

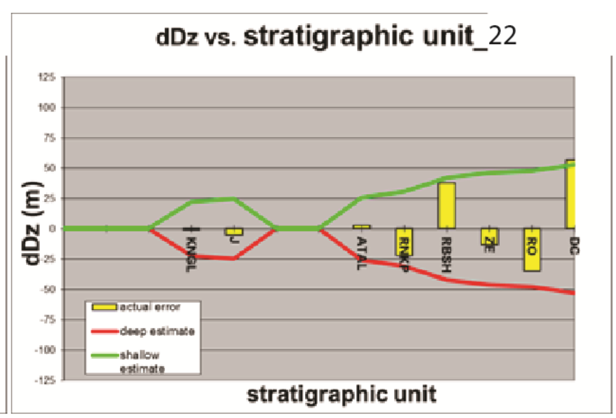

Dz vs. stratigraphic unit_ 50
Dz(m)
actual error
deep estimate
shallow estimate
CK
KNGL
UJ
RNRO
RBSH
ZE
RO
DC
stratigraphic unit

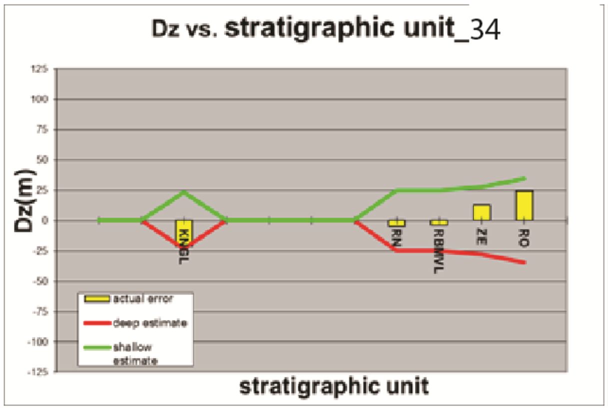

dDz vs. stratigraphic unit_50
dDz (m)
actual error
deep estimate
shallow estimate
CK
KNGL
UJ
RNRO
RBSH
ZE
RO
DC
stratigraphic unit

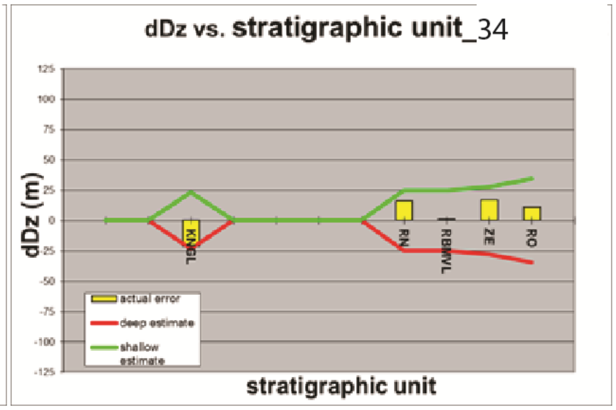

Dz vs. stratigraphic unit_ 43
Dz(m)
KNGL
ATAL
RNKP
RBMV
ZE
RO
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

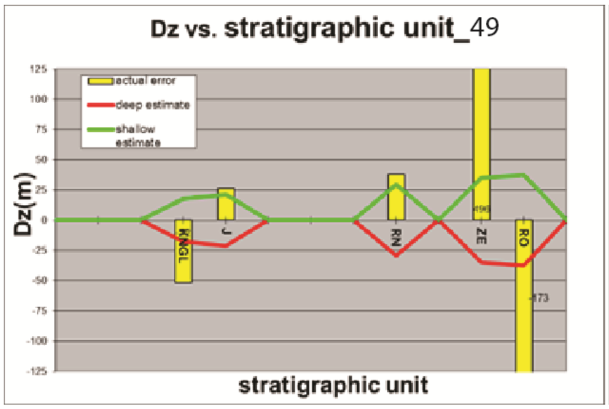

dDz vs. stratigraphic unit_43
dDz (m)
KNGL
ATAL
RNKP
RBMV
ZE
RO
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

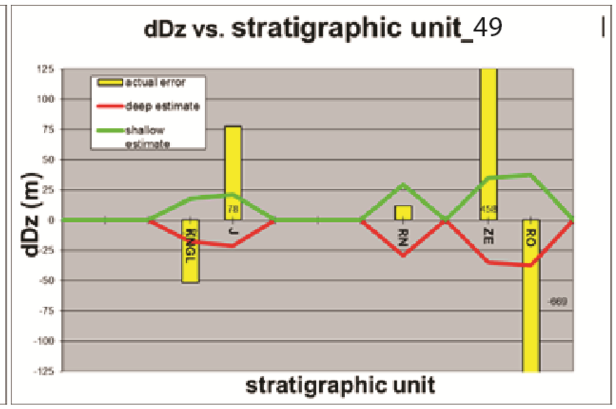

Dz vs. stratigraphic unit_ 22
Dz(m)
KNGL
UJ
ATAL
RNKP
RBSH
ZE
RO
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

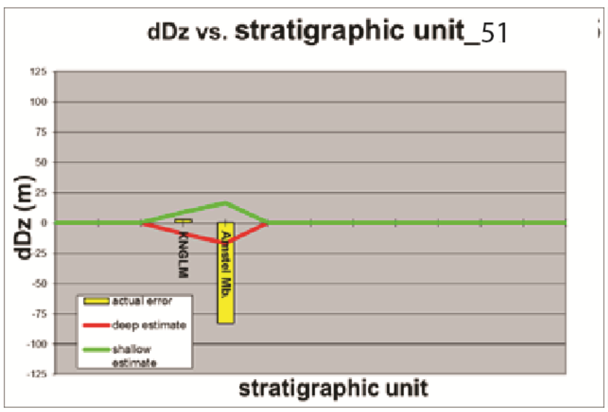

dDz vs. stratigraphic unit_22
dDz (m)
KNGL
UJ
ATAL
RNKP
RBSH
ZE
RO
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

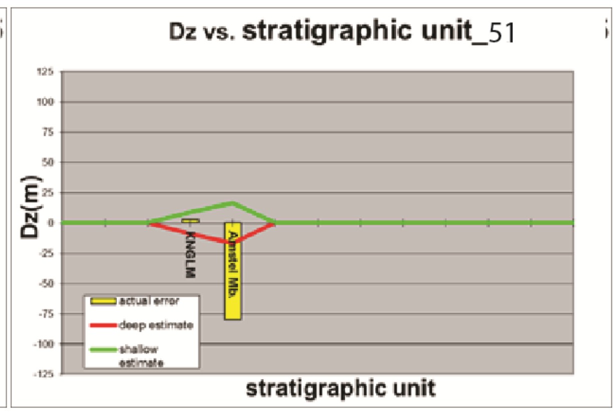

Dz vs. stratigraphic unit_34
Dz(m)
KNGL
RN
RBMVL
ZE
RO
actual error
deep estimate
shallow estimate
stratigraphic unit

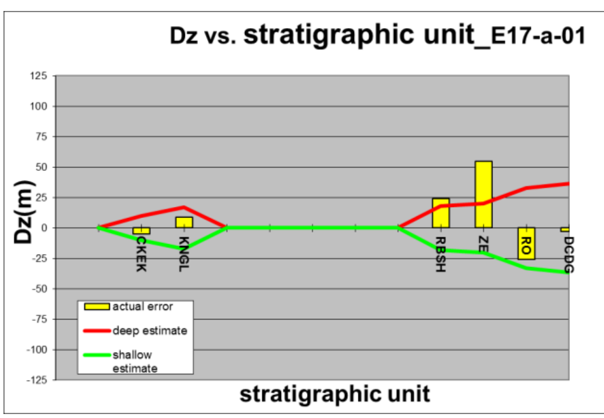

dDz vs. stratigraphic unit_34
dDz (m)
KNGL
RN
RBMVL
ZE
RO
actual error
deep estimate
shallow estimate
stratigraphic unit

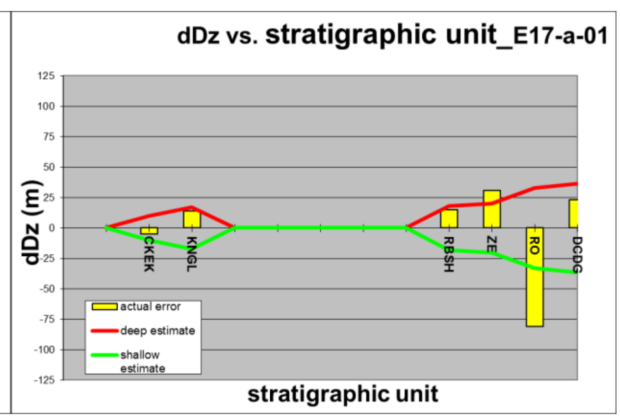

Dz vs. stratigraphic unit_49
Dz(m)
actual error
deep estimate
shallow estimate
KNGL
J
RN
ZE
RO
stratigraphic unit

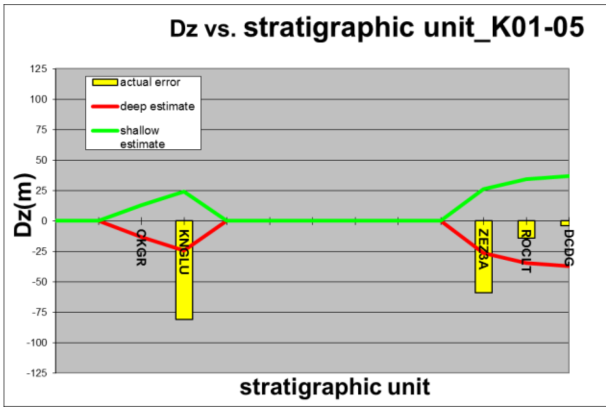

dDz vs. stratigraphic unit_49
dDz (m)
actual error
deep estimate
shallow estimate
78
KNGL
J
RN
ZE
RO
stratigraphic unit

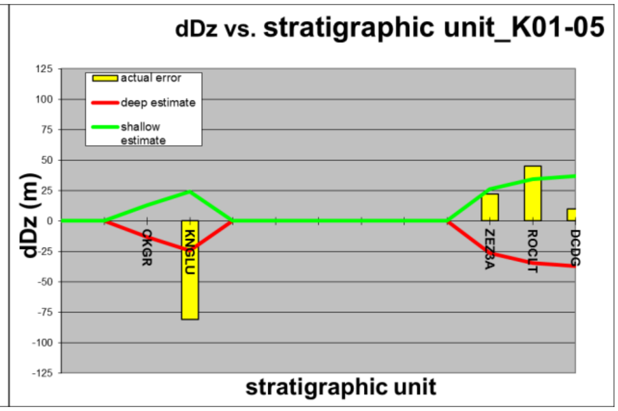

dDz vs. stratigraphic unit_51
dDz (m)
KNGLM
Amstel Mb.
actual error
deep estimate
shallow estimate
stratigraphic unit

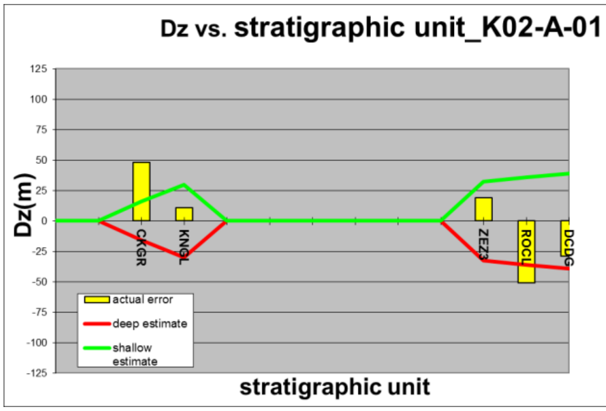

Dz vs. stratigraphic unit_51
Dz(m)
KNGLM
Amstel Mb.
actual error
deep estimate
shallow estimate
stratigraphic unit

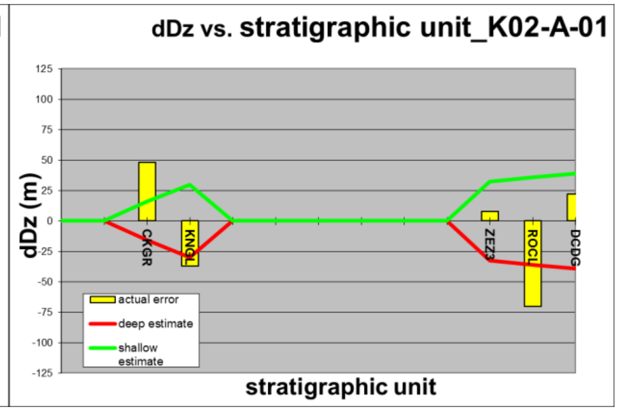

Dz vs. stratigraphic unit_E17-a-01
Dz(m)
CKEK
KNGL
RBSH
ZE
RO
DCDG
actual error
deep estimate
shallow estimate
stratigraphic unit

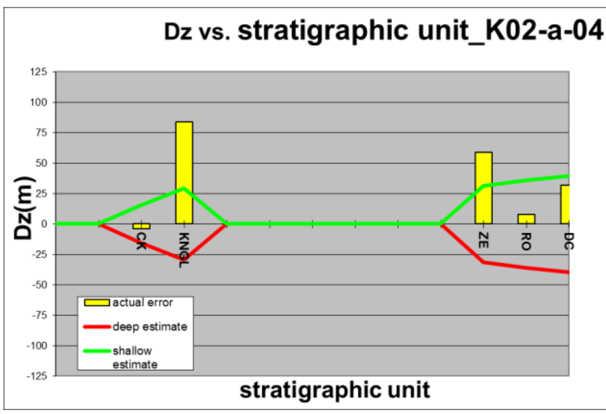

dDz vs. stratigraphic unit_E17-a-01
dDz (m)
CKEK
KNGL
RBSH
ZE
RO
DCDG
actual error
deep estimate
shallow estimate
stratigraphic unit

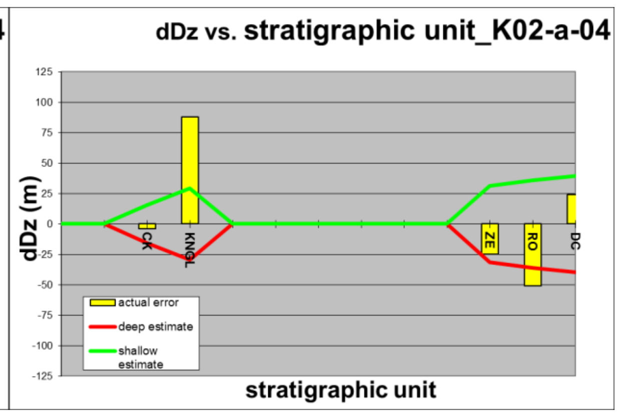

Dz vs. stratigraphic unit_K01-05
Dz(m)
actual error
deep estimate
shallow estimate
CKGR
KNGLU
ZEZ3A
ROCLT
DCDG
stratigraphic unit

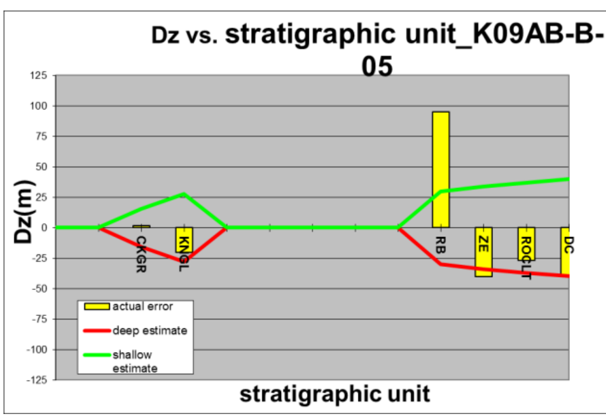

dDz vs. stratigraphic unit_K01-05
dDz (m)
actual error
deep estimate
shallow estimate
CKGR
KNGLU
ZEZ3A
ROCLT
DCDG
stratigraphic unit

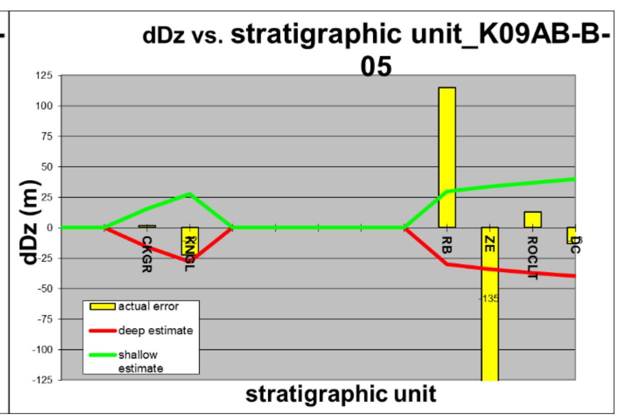

Dz vs. stratigraphic unit_K02-A-01
Dz(m)
CKGR
KNGL
ZEZ3
ROCL
DCDG
actual error
deep estimate
shallow estimate
stratigraphic unit

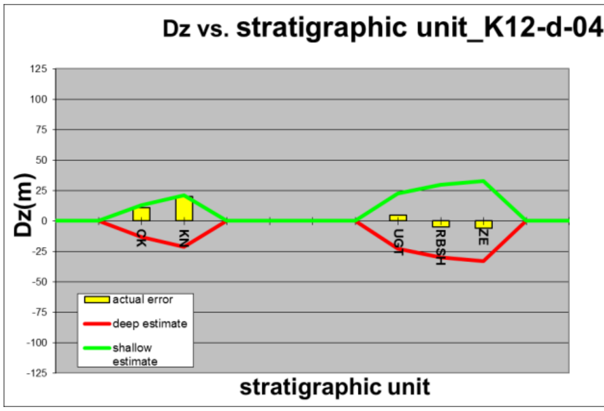

dDz vs. stratigraphic unit_K02-A-01
dDz (m)
CKGR
KNGLU
ZEZ3
ROCLT
DCDG
actual error
deep estimate
shallow estimate
stratigraphic unit

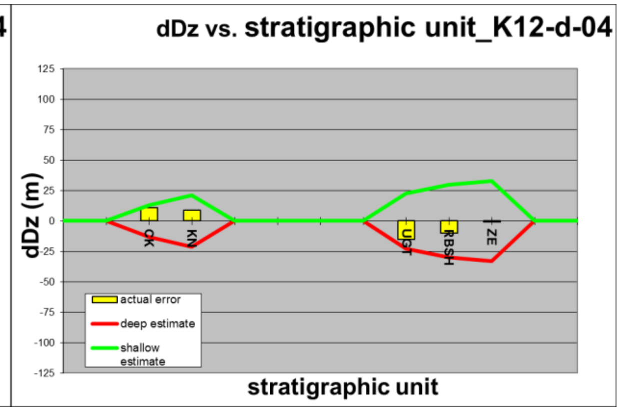

Dz vs. stratigraphic unit_K02-a-04
Dz(m)
CK
KNGL
ZE
RO
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

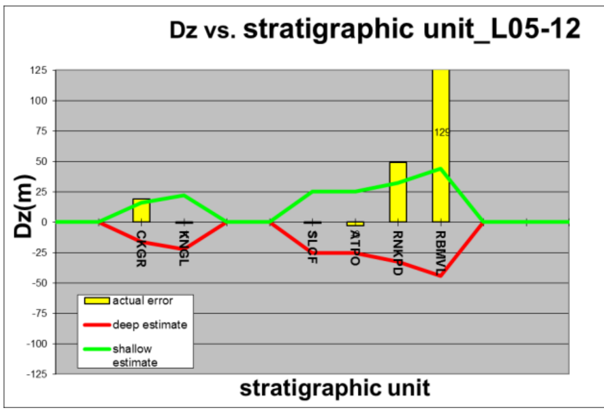

dDz vs. stratigraphic unit_K02-a-04
dDz (m)
CK
KNGL
ZE
RO
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

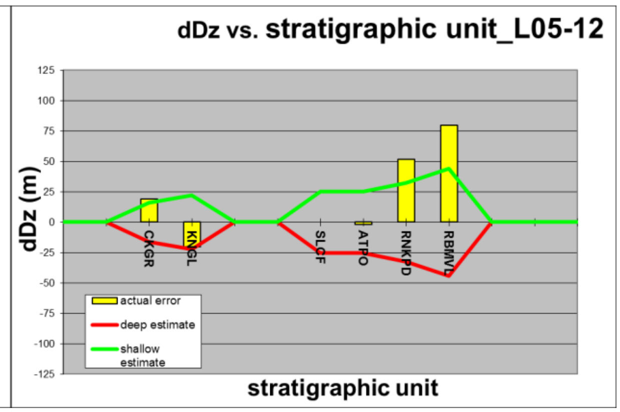

Dz vs. stratigraphic unit_K09AB-B-05
Dz(m)
CKGR
KNGL
RB
ZE
ROCLT
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

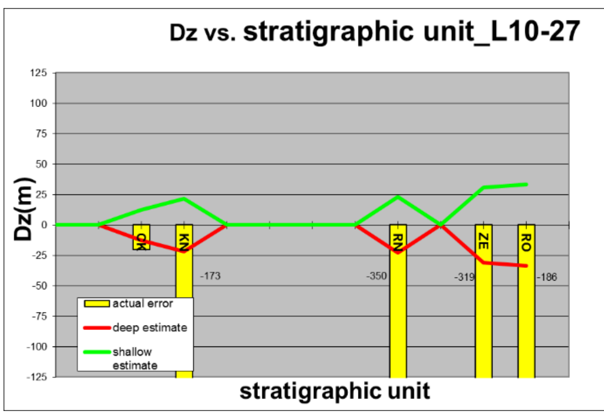

dDz vs. stratigraphic unit_K09AB-B-05
dDz (m)
CKGR
KNGL
RB
ZE
-135
ROCLT
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

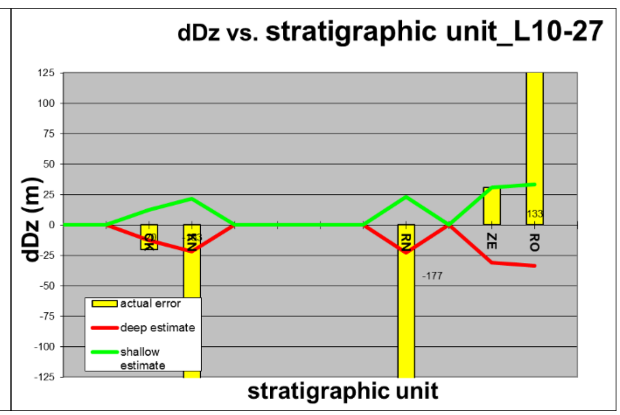

Dz vs. stratigraphic unit_K12-d-04
Dz(m)
CK
KN
UGT
RBSH
ZE
actual error
deep estimate
shallow estimate
stratigraphic unit

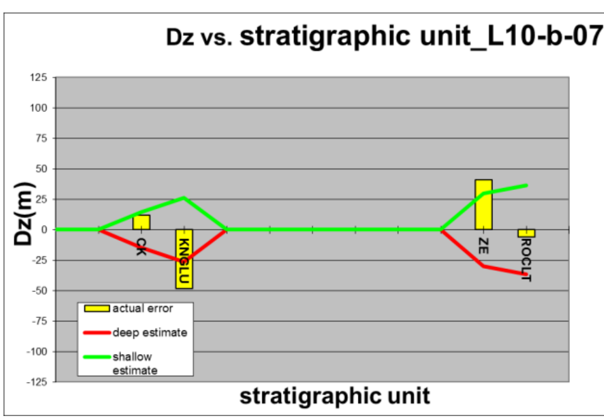

dDz vs. stratigraphic unit_K12-d-04
dDz (m)
CK
KN
UGT
RBSH
ZE
actual error
deep estimate
shallow estimate
stratigraphic unit

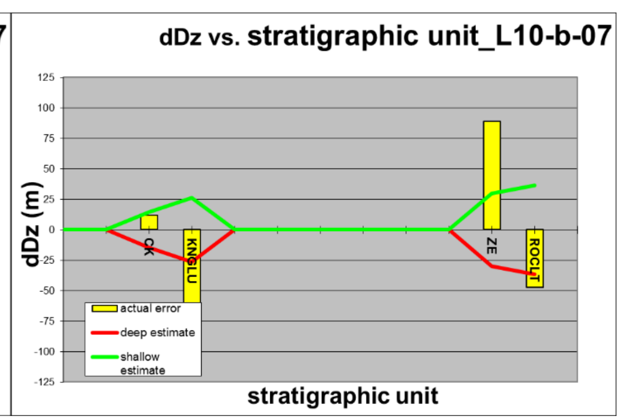

Dz vs. stratigraphic unit_L05-12
Dz(m)
CKGR
KNGL
SLGF
ATPO
RNKPD
RBMVD
actual error
deep estimate
shallow estimate
stratigraphic unit

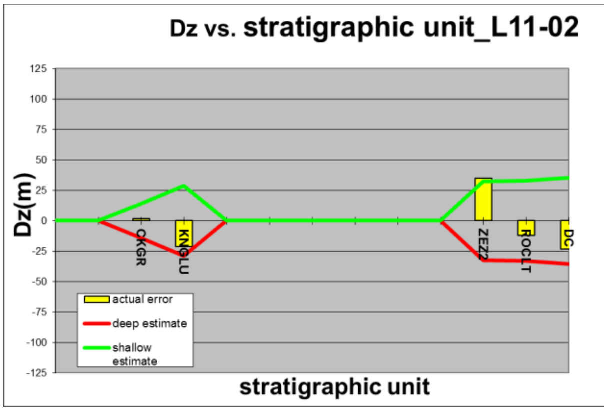

dDz vs. stratigraphic unit_L05-12
dDz (m)
CKGR
KNGL
SLGF
ATPO
RNKPD
RBMVD
actual error
deep estimate
shallow estimate
stratigraphic unit

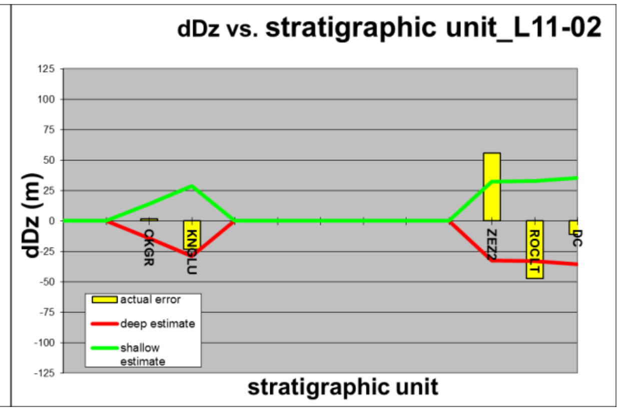

Dz vs. stratigraphic unit_L10-27
Dz(m)
CK
KN
RN
ZE
RO
-173
-350
-319
-186
actual error
deep estimate
shallow estimate
stratigraphic unit

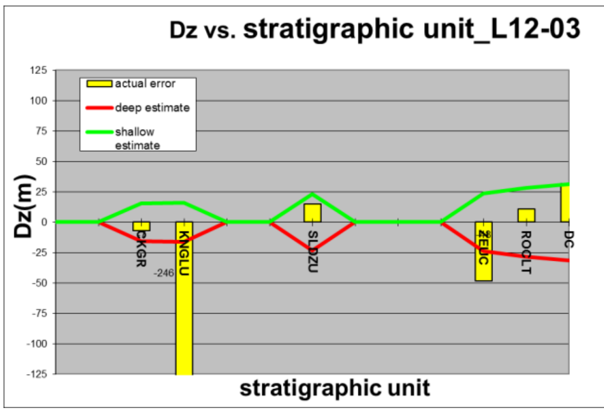

dDz vs. stratigraphic unit_L10-27
dDz (m)
CK
KN
RN
ZE
RO
-177
133
actual error
deep estimate
shallow estimate
stratigraphic unit

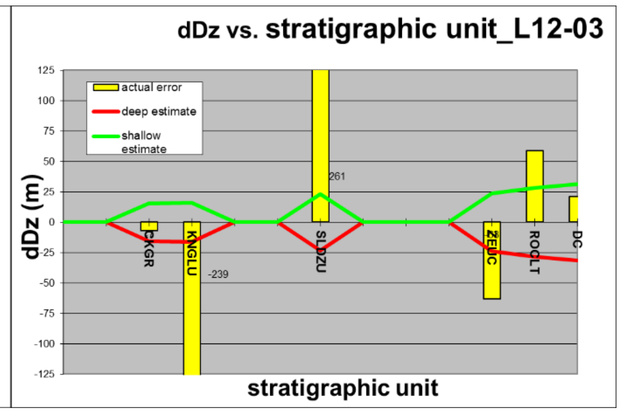

Dz vs. stratigraphic unit_L10-b-07
Dz(m)
CK
KNGLU
ZE
ROCLT
actual error
deep estimate
shallow estimate
stratigraphic unit

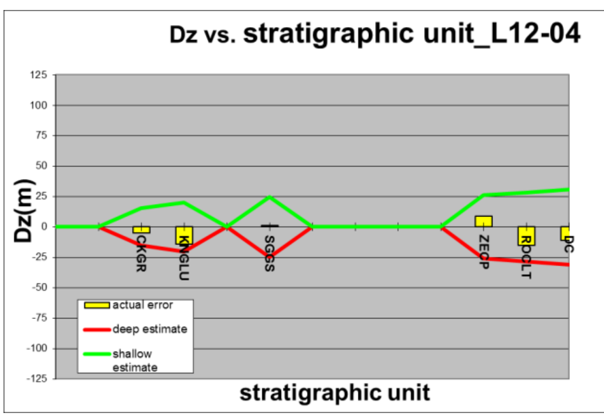

dDz vs. stratigraphic unit_L10-b-07
dDz (m)
CK
KNGLU
ZE
ROCLT
actual error
deep estimate
shallow estimate
stratigraphic unit

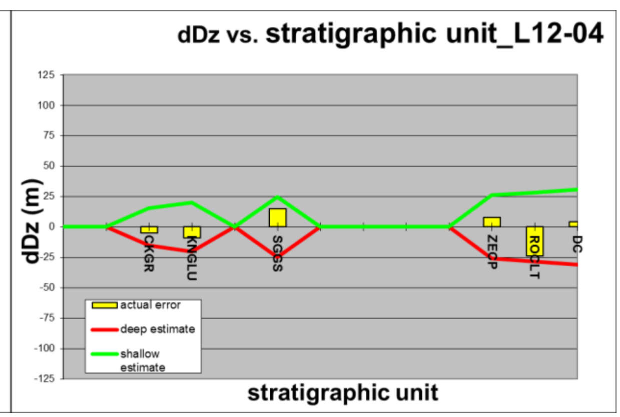

Dz vs. stratigraphic unit_L11-02
Dz(m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
CKGR
KNGLU
ZEZ2
ROCLT
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

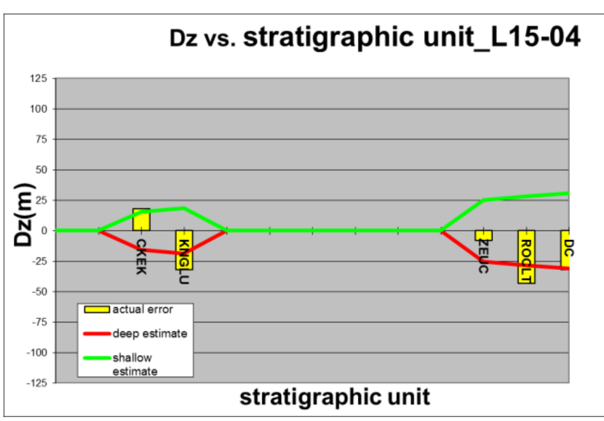

dDz vs. stratigraphic unit_L11-02
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
CKGR
KNGLU
ZEZ2
ROCLT
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

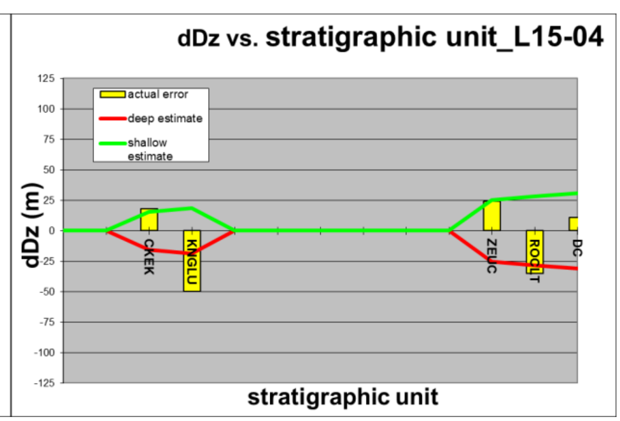

Dz vs. stratigraphic unit_L12-03
Dz(m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
actual error
deep estimate
shallow estimate
CKGR
KNGLU
-246
SLDZU
ZEUC
ROCLT
DC
stratigraphic unit

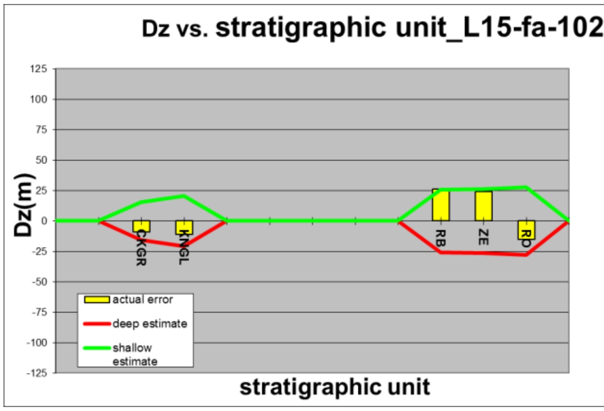

dDz vs. stratigraphic unit_L12-03
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
actual error
deep estimate
shallow estimate
261
CKGR
KNGLU
-239
SLDZU
ZEUC
ROCLT
DC
stratigraphic unit

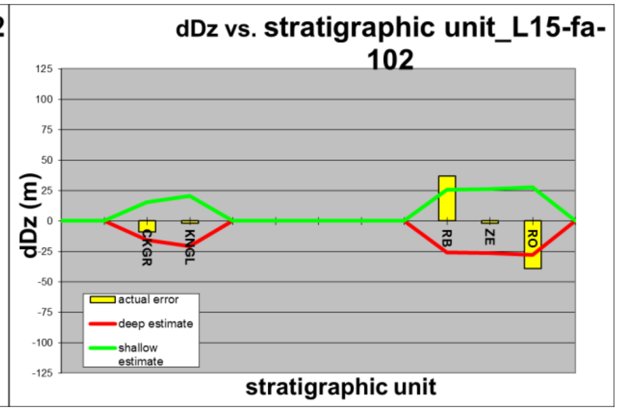

Dz vs. stratigraphic unit_L12-04
Dz(m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
CKGR
KNGLU
SGGS
ZECP
ROCLT
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

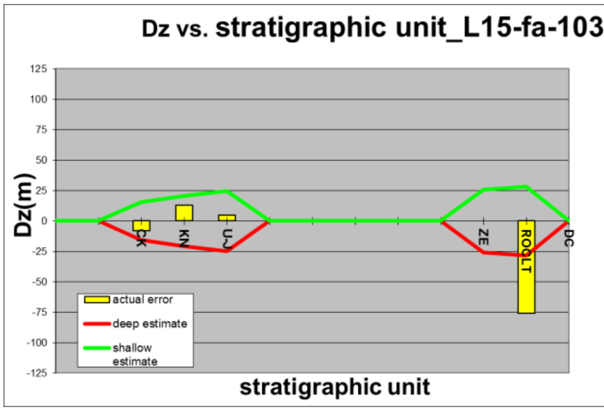

dDz vs. stratigraphic unit_L12-04
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
CKGR
KNGLU
SGGS
ZECP
ROCLT
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

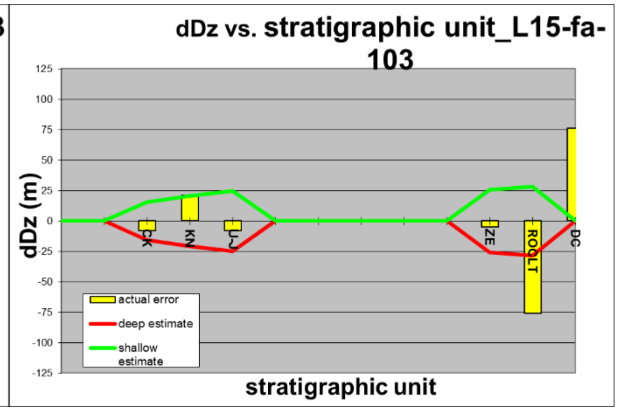

Dz vs. stratigraphic unit_L15-04
Dz(m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
CKEK
KNGLU
ZEUC
ROCLT
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

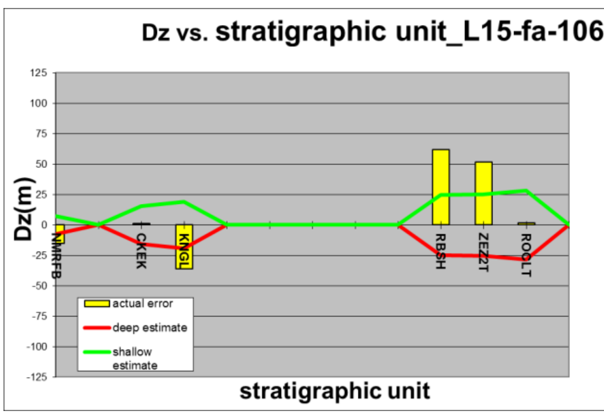

dDz vs. stratigraphic unit_L15-04
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
actual error
deep estimate
shallow estimate
CKEK
KNGLU
ZEUC
ROCLT
DC
stratigraphic unit

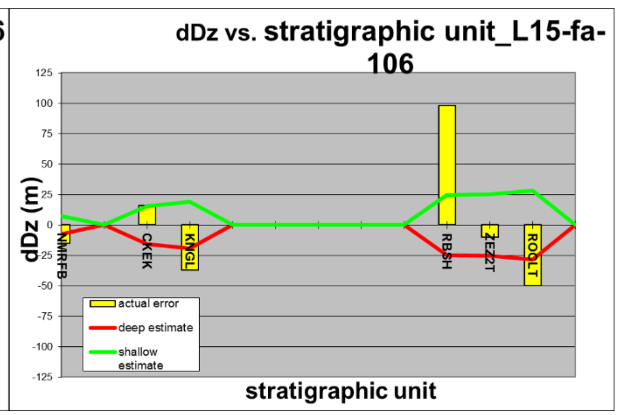

Dz vs. stratigraphic unit_L15-fa-102
Dz(m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
CKGR
KNGL
RB
ZE
RO
actual error
deep estimate
shallow estimate
stratigraphic unit


dDz vs. stratigraphic unit_L15-fa-102
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
CKGR
KNGL
RB
ZE
RO
actual error
deep estimate
shallow estimate
stratigraphic unit

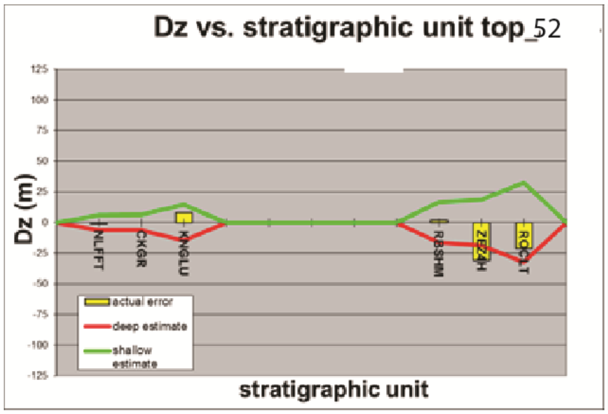

Dz vs. stratigraphic unit_L15-fa-103
Dz(m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
CK
KN
U-J
ZE
ROQLT
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

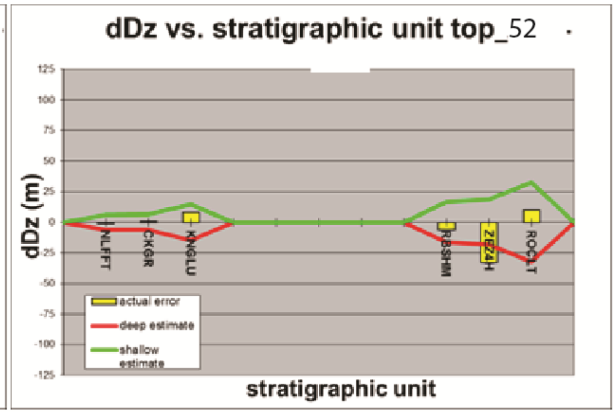

dDz vs. stratigraphic unit_L15-fa-103
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
CK
KN
U-J
ZE
ROQLT
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

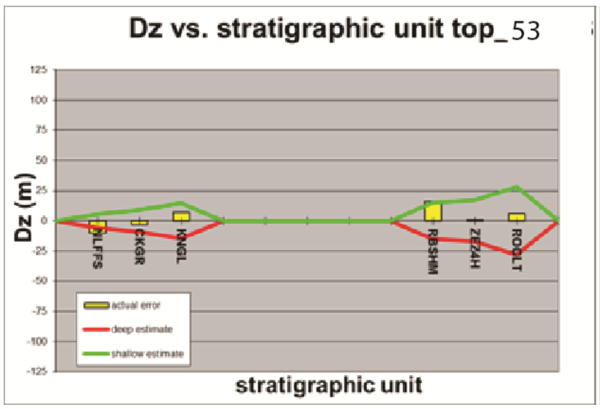

Dz vs. stratigraphic unit_L15-fa-106
Dz(m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
NMRFB
CKEK
KNGL
RBSH
ZEZ2T
ROQLT
actual error
deep estimate
shallow estimate
stratigraphic unit

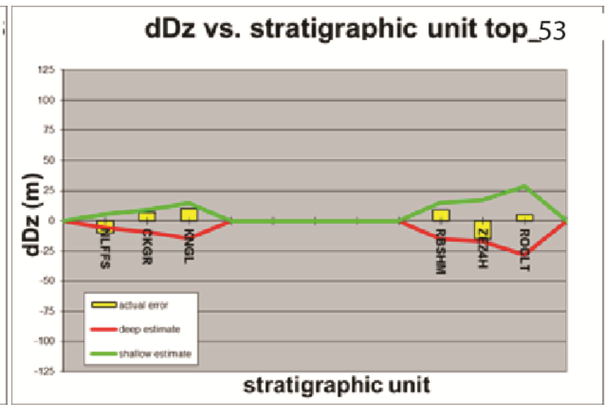

dDz vs. stratigraphic unit_L15-fa-106
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
NMRFB
CKEK
KNGL
RBSH
ZEZ2T
ROQLT
actual error
deep estimate
shallow estimate
stratigraphic unit

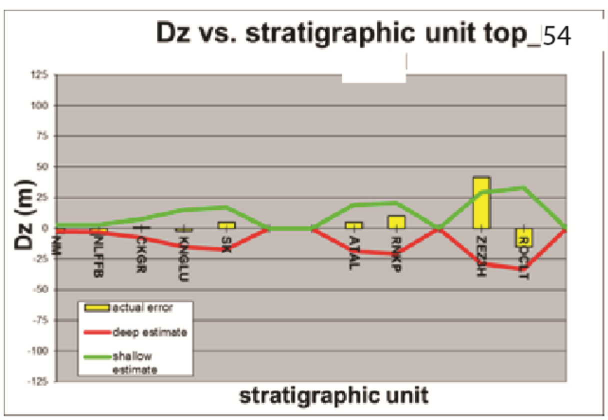
NAM

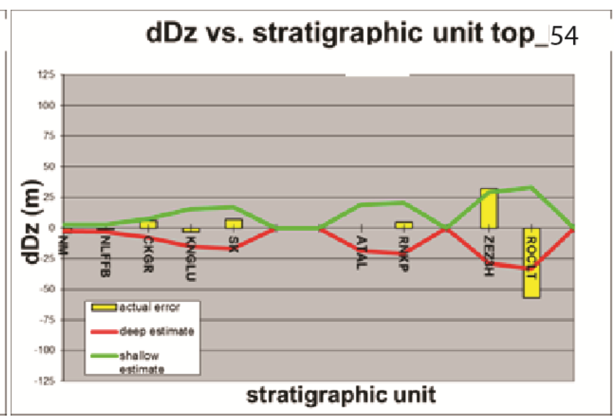

Dz vs. stratigraphic unit top_52
Dz (m)
stratigraphic unit
NLFFT
CKGR
KNGLU
RBSHM
ZEZ4H
ROCLT
actual error
deep estimate
shallow estimate

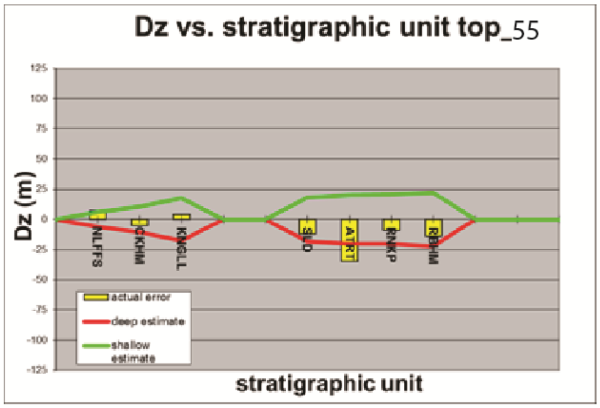

dDz vs. stratigraphic unit top_52
dDz (m)
stratigraphic unit
NLFFT
CKGR
KNGLU
RBSHM
ZEZ4H
ROCLT
actual error
deep estimate
shallow estimate

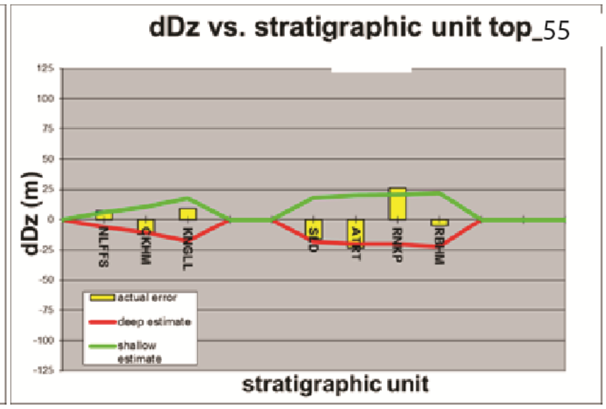

Dz vs. stratigraphic unit top_53
Dz (m)
stratigraphic unit
NLFFS
CKGR
KNGL
RBSHM
ZEZ4H
ROCLT
actual error
deep estimate
shallow estimate

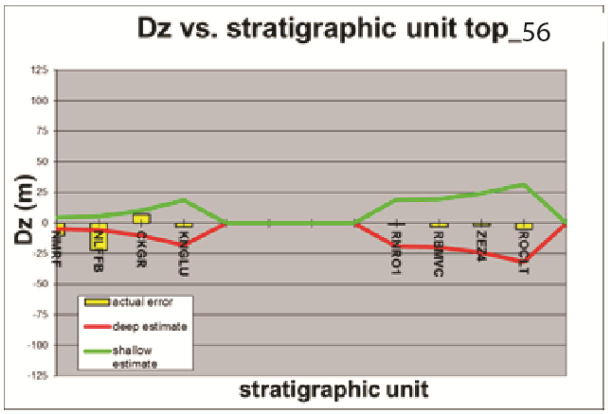

dDz vs. stratigraphic unit top_53
dDz (m)
stratigraphic unit
NLFFS
CKGR
KNGL
RBSHM
ZEZ4H
ROCLT
actual error
deep estimate
shallow estimate

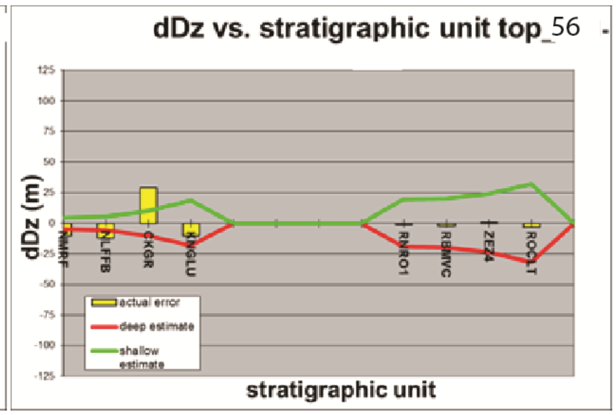

Dz vs. stratigraphic unit top_54
Dz (m)
stratigraphic unit
NM
NLFFB
CKGR
KNGLU
SK
ATAL
RNKP
ZEZ3H
ROCLT
actual error
deep estimate
shallow estimate

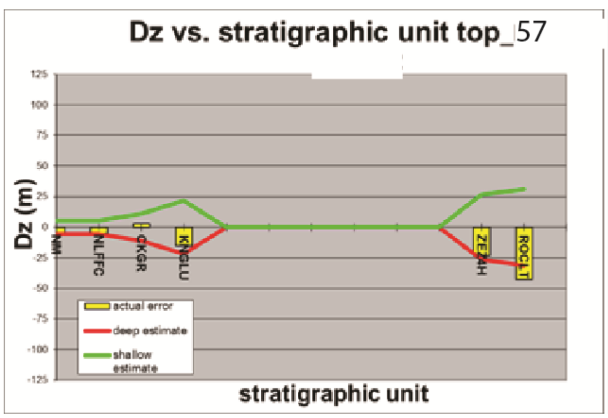

dDz vs. stratigraphic unit top_54
dDz (m)
stratigraphic unit
NM
NLFFB
CKGR
KNGLU
SK
ATAL
RNKP
ZEZ3H
ROCLT
actual error
deep estimate
shallow estimate

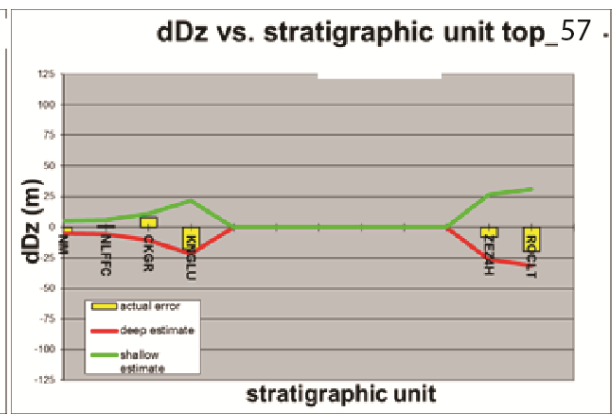

Dz vs. stratigraphic unit top_55
Dz (m)
NLFFS
CKHM
KNGLL
SLD
ATRT
RNKP
RBHM
actual error
deep estimate
shallow estimate
stratigraphic unit

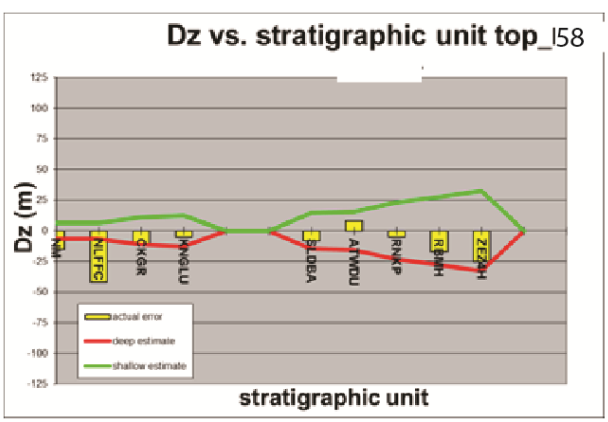

dDz vs. stratigraphic unit top_55
dDz (m)
NLFFS
CKHM
KNGLL
SLD
ATRT
RNKP
RBHM
actual error
deep estimate
shallow estimate
stratigraphic unit

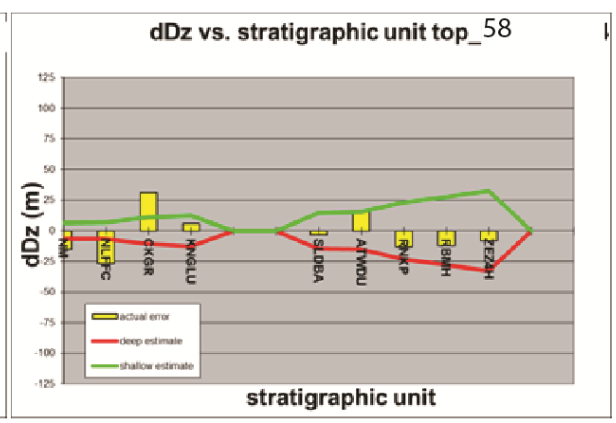

Dz vs. stratigraphic unit top_56
Dz (m)
NMRF
NLFFB
CKGR
KNGLU
RNRO1
RBMVC
ZEZ4
ROCLT
actual error
deep estimate
shallow estimate
stratigraphic unit

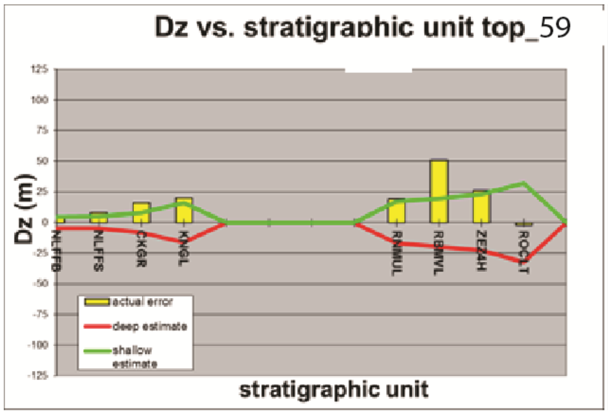

dDz vs. stratigraphic unit top_56
dDz (m)
NMRF
NLFFB
CKGR
KNGLU
RNRO1
RBMVC
ZEZ4
ROCLT
actual error
deep estimate
shallow estimate
stratigraphic unit

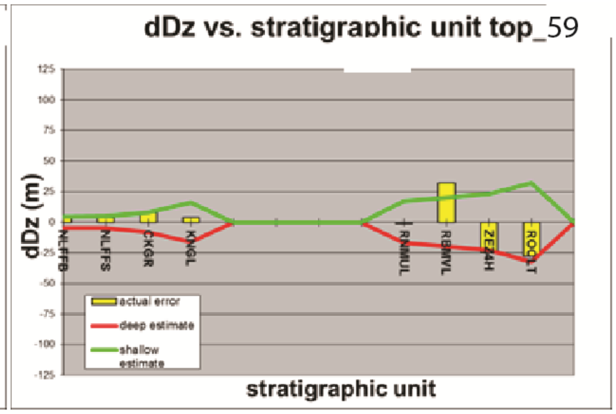

Dz vs. stratigraphic unit top_57
Dz (m)
NLFFC
CKGR
KNGLU
ZEZ4H
ROCLT
actual error
deep estimate
shallow estimate
stratigraphic unit

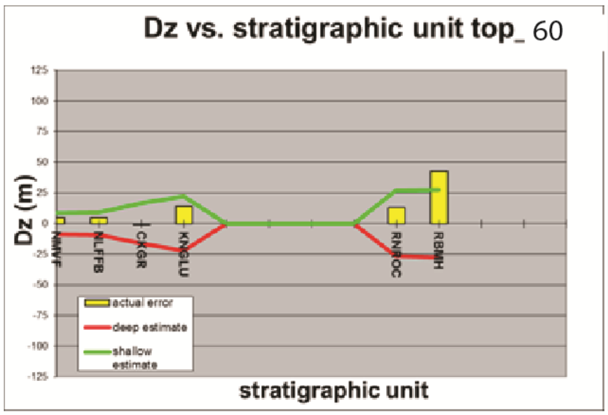

dDz vs. stratigraphic unit top_57
dDz (m)
NLFFC
CKGR
KNGLU
ZEZ4H
ROCLT
actual error
deep estimate
shallow estimate
stratigraphic unit

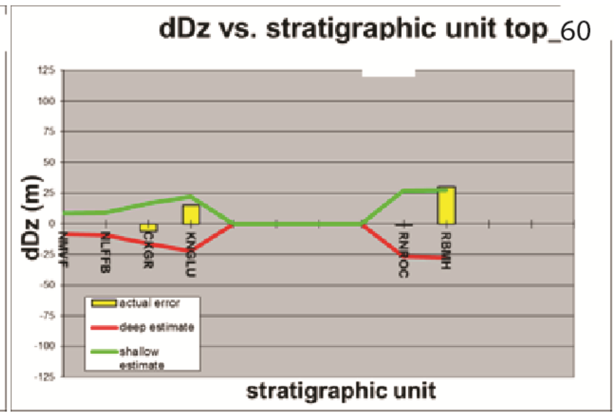

Dz vs. stratigraphic unit top_58
Dz (m)
NLFFC
CKGR
KNGLU
SLDBA
ATWDU
RNKP
RBNIH
ZEZ4H
actual error
deep estimate
shallow estimate
stratigraphic unit

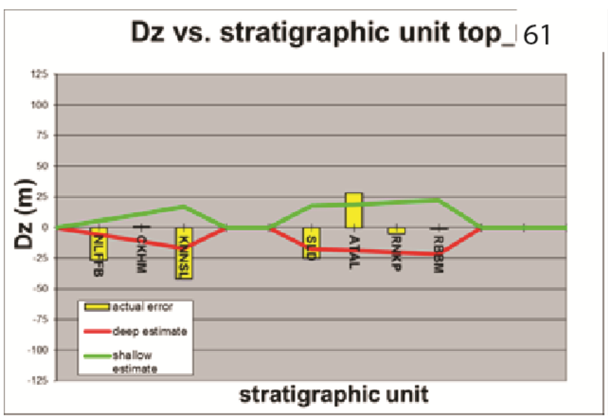

dDz vs. stratigraphic unit top_58
dDz (m)
NLFFC
CKGR
KNGLU
SLDBA
ATWDU
RNKP
RBNIH
ZEZ4H
actual error
deep estimate
shallow estimate
stratigraphic unit

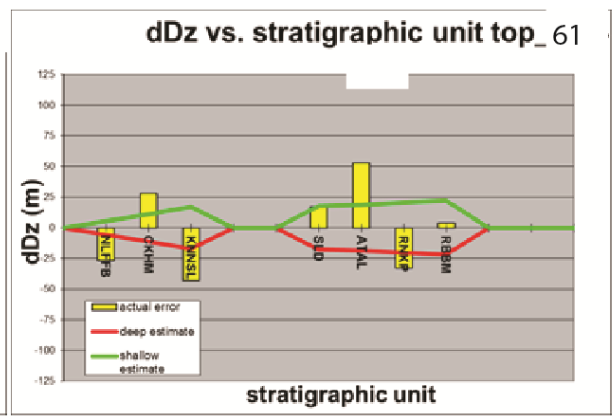

Dz vs. stratigraphic unit top_59
Dz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
NLFFS
CKGR
KNGL
RNMUL
RBMVL

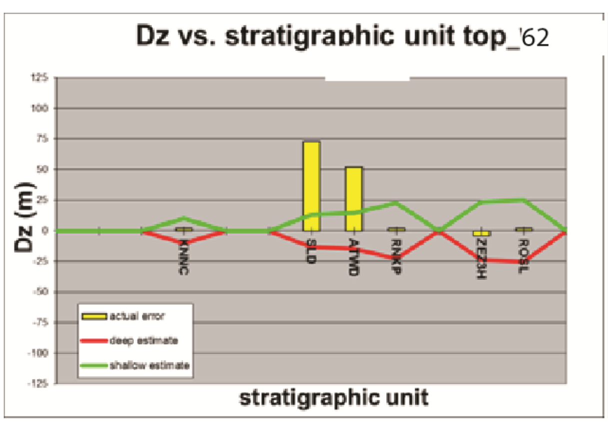

dDz vs. stratigraphic unit top_59
dDz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
NLFFS
CKGR
KNGL
RNMUL
RBMVL

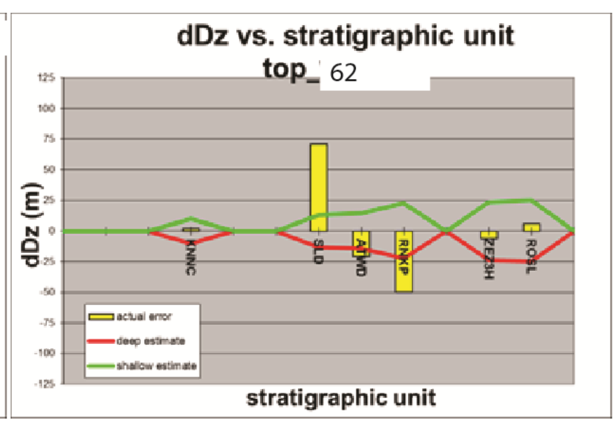

Dz vs. stratigraphic unit top_ 60
Dz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
NLFFS
CKGR
KNGLU
RNROC
RBBMH

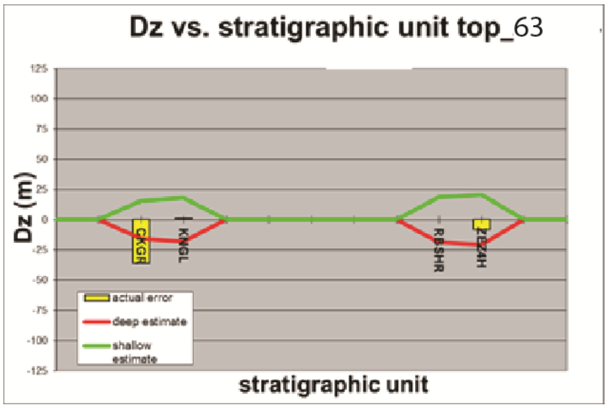

dDz vs. stratigraphic unit top_60
dDz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
NLFFB
CKGR
KNGLU
RNROC
RBBMH

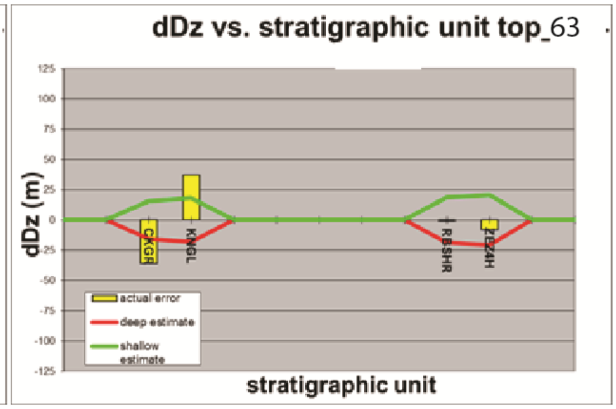

Dz vs. stratigraphic unit top_ 61
Dz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
NLFFB
CKHM
KNNSL
SLD
ATAL
RNKP
RBBM

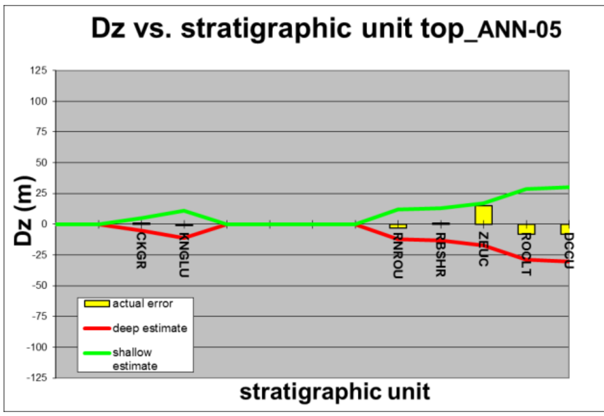

dDz vs. stratigraphic unit top_ 61
dDz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
NLFFB
CKHM
KNNSL
SLD
ATAL
RNKP
RBBM

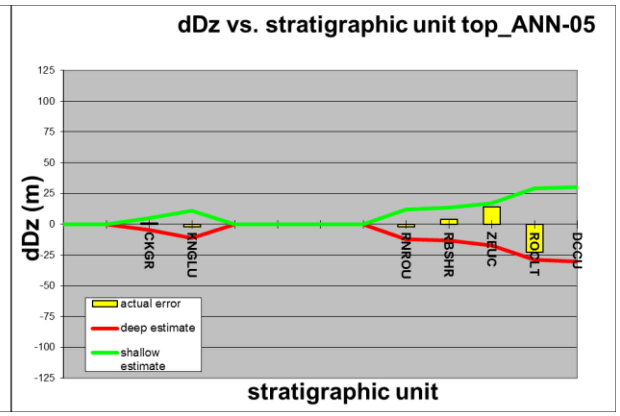

Dz vs. stratigraphic unit top_ 62
Dz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
KNNC
SLD
ATMD
RNKP
ZEZ3H
ROSL

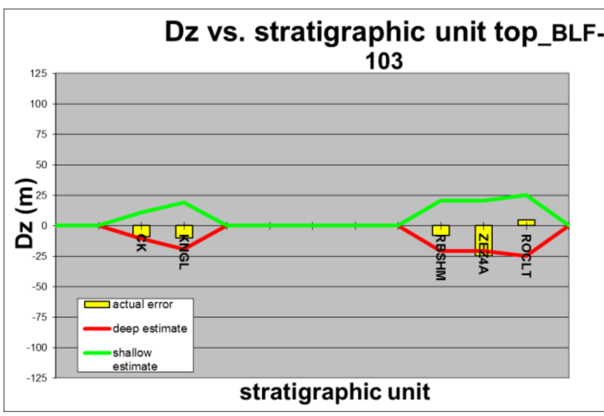

dDz vs. stratigraphic unit top_ 62
dDz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
KNNC
SLD
ATMD
RNKP
ZEZ3H
ROSL

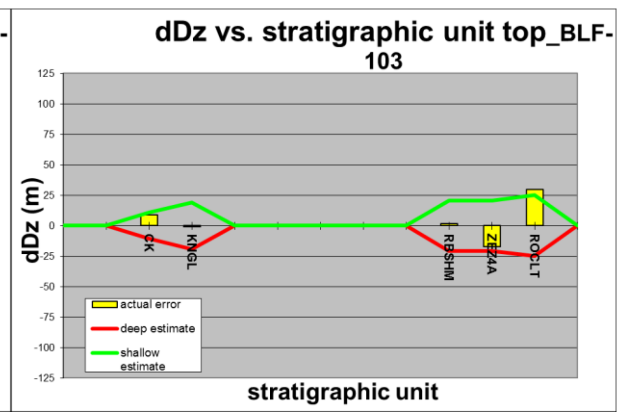

Dz vs. stratigraphic unit top_63
Dz (m)
CKGR
KNGL
RBSHR
ZEZ4H
actual error
deep estimate
shallow estimate
stratigraphic unit

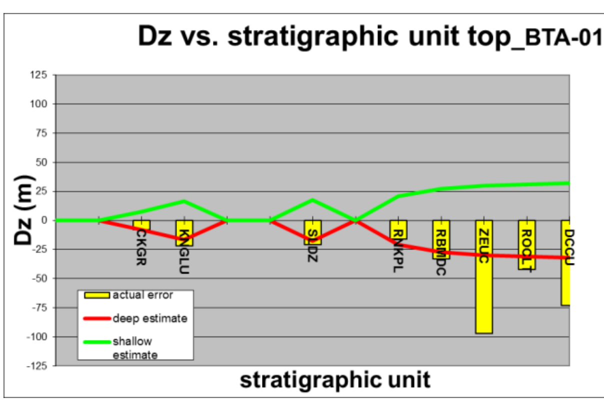

dDz vs. stratigraphic unit top_63
dDz (m)
CKGR
KNGL
RBSHR
ZEZ4H
actual error
deep estimate
shallow estimate
stratigraphic unit

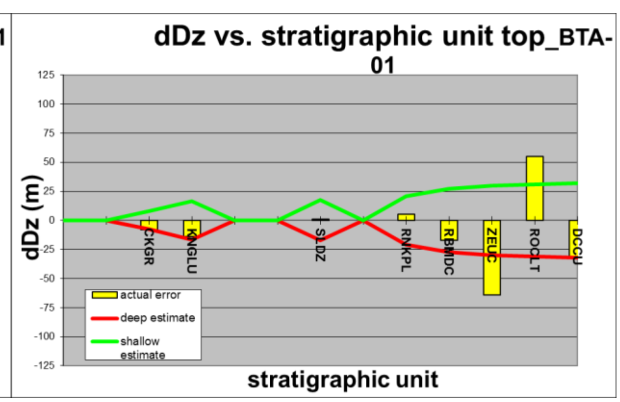

Dz vs. stratigraphic unit top_ANN-05
Dz (m)
CKGR
KNGLU
RNROU
RBSHR
ZEUC
ROCLT
DCCU
actual error
deep estimate
shallow estimate
stratigraphic unit

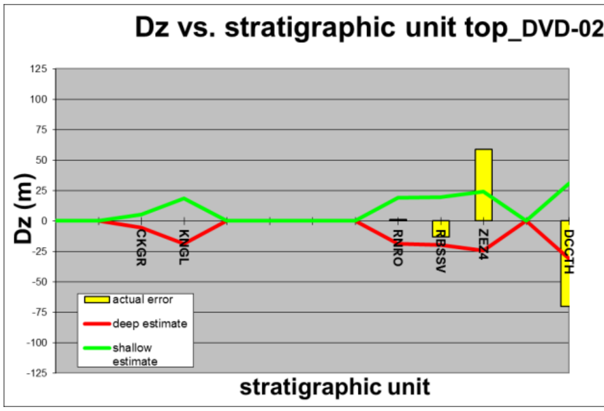

dDz vs. stratigraphic unit top_ANN-05
dDz (m)
CKGR
KNGLU
RNROU
RBSHR
ZEUC
ROCLT
DCCU
actual error
deep estimate
shallow estimate
stratigraphic unit

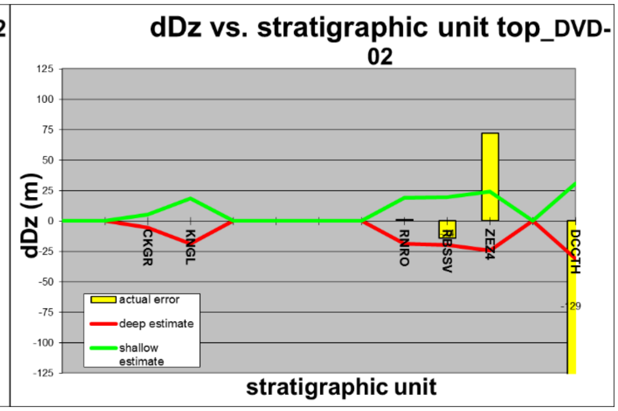

Dz vs. stratigraphic unit top_BLF-103
Dz (m)
CK
KNGL
RBSHM
ZEZ4A
ROCLT
actual error
deep estimate
shallow estimate
stratigraphic unit

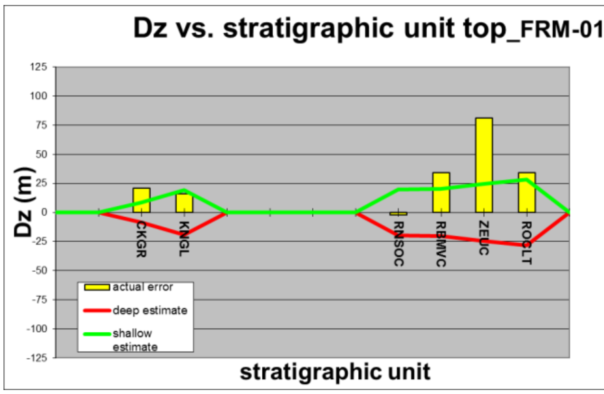

dDz vs. stratigraphic unit top_BLF-103
dDz (m)
CK
KNGL
RBSHM
ZEZ4A
ROCLT
actual error
deep estimate
shallow estimate
stratigraphic unit

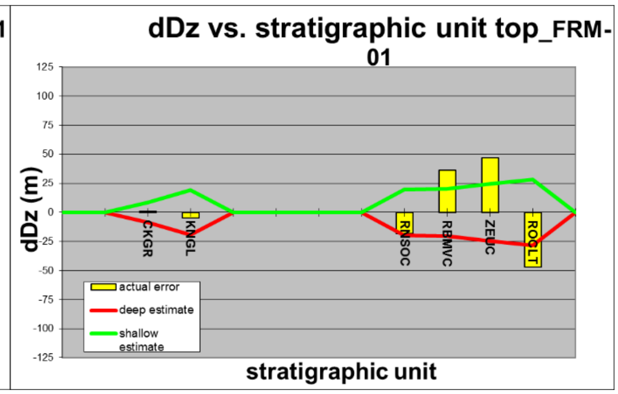

Dz vs. stratigraphic unit top_BTA-01
Dz (m)
CKGR
KNGLU
SLDZ
RNKPL
RBMDC
ZEUC
ROCLT
DCCU
actual error
deep estimate
shallow estimate
stratigraphic unit

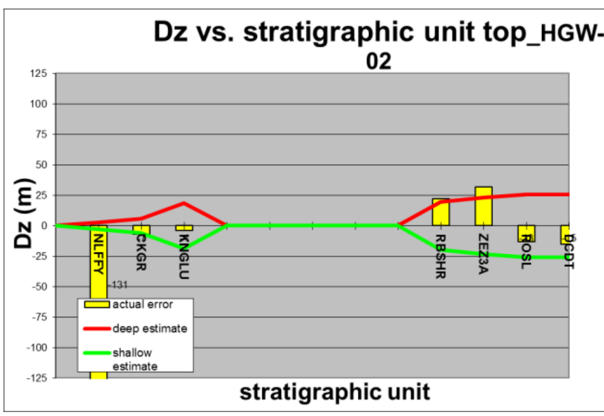

dDz vs. stratigraphic unit top_BTA-01
dDz (m)
CKGR
KNGLU
SLDZ
RNKPL
RBMDC
ZEUC
ROCLT
DCCU
actual error
deep estimate
shallow estimate
stratigraphic unit

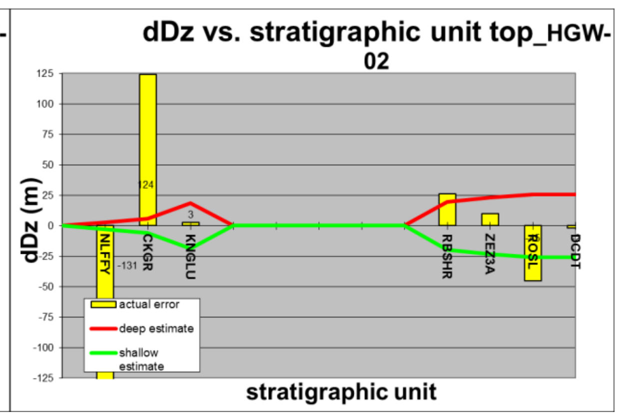

Dz vs. stratigraphic unit top_DVD-02
Dz (m)
stratigraphic unit
CKGR
KNGL
RNRO
RBSSV
ZEZ4
DCCTH
actual error
deep estimate
shallow estimate

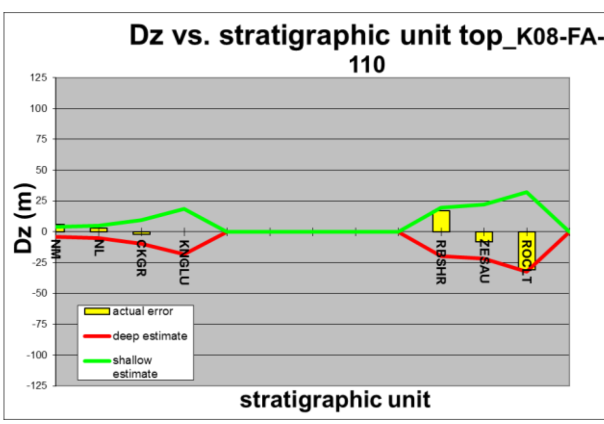

dDz vs. stratigraphic unit top_DVD-02
dDz (m)
stratigraphic unit
CKGR
KNGL
RNRO
RBSSV
ZEZ4
DCCTH
-129
actual error
deep estimate
shallow estimate

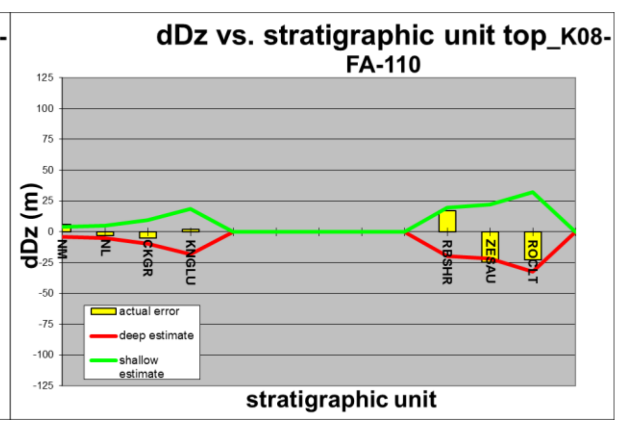

Dz vs. stratigraphic unit top_FRM-01
Dz (m)
stratigraphic unit
CKGR
KNGL
RNSOC
RBMVC
ZEUC
ROSLT
actual error
deep estimate
shallow estimate

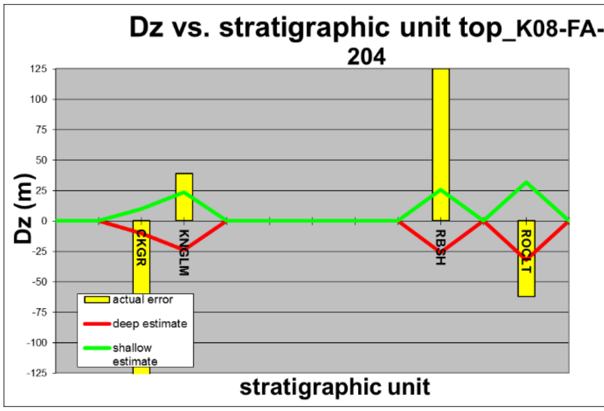

dDz vs. stratigraphic unit top_FRM-01
dDz (m)
stratigraphic unit
CKGR
KNGL
RNSOC
RBMVC
ZEUC
ROSLT
actual error
deep estimate
shallow estimate

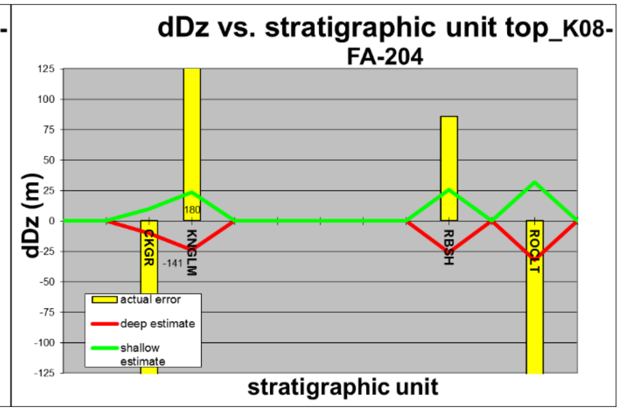

Dz vs. stratigraphic unit top_HGW-02
Dz (m)
stratigraphic unit
NLFFY
CKGR
KNGLU
RBSHR
ZEZ3A
ROSL
DCDT
-131
actual error
deep estimate
shallow estimate

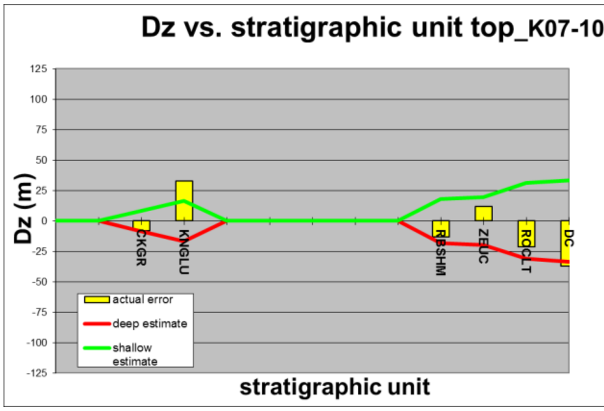

dDz vs. stratigraphic unit top_HGW-02
dDz (m)
stratigraphic unit
NLFFY
CKGR
KNGLU
RBSHR
ZEZ3A
ROSL
DCDT
124
3
-131
actual error
deep estimate
shallow estimate

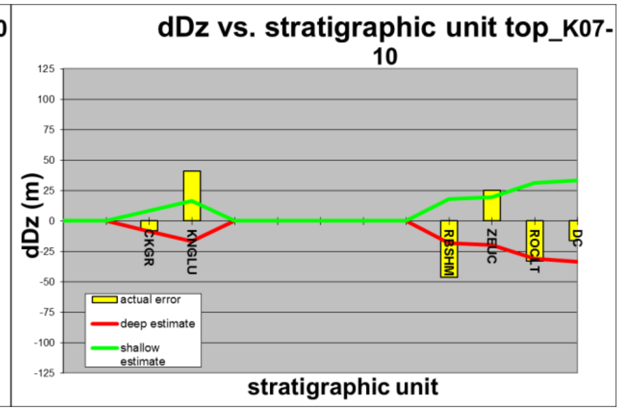

Dz vs. stratigraphic unit top_K08-FA-110
Dz (m)
stratigraphic unit
NM
NL
CKGR
KNGLU
RBSHR
ZESAU
ROCLT
actual error
deep estimate
shallow estimate

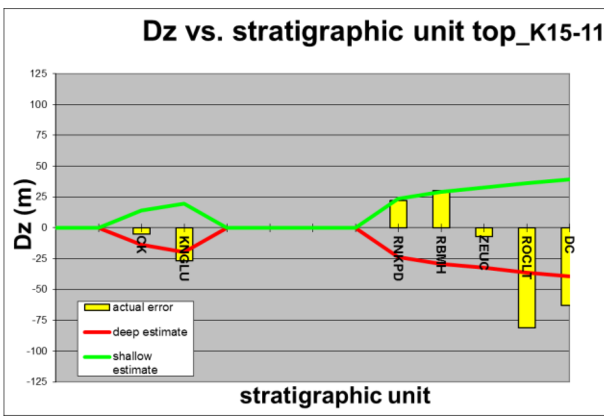

dDz vs. stratigraphic unit top_K08-FA-110
dDz (m)
stratigraphic unit
NM
NL
CKGR
KNGLU
RBSHR
ZESAU
ROCLT
actual error
deep estimate
shallow estimate

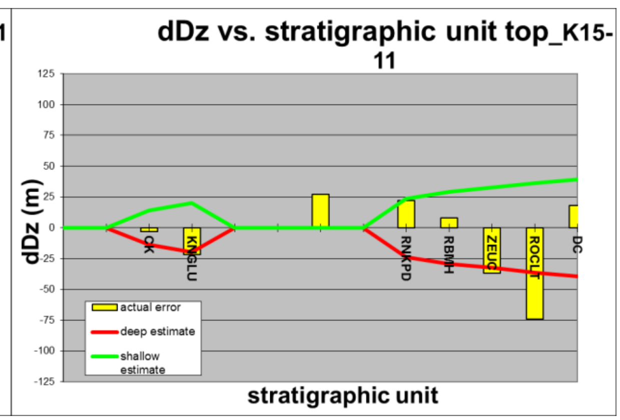

Dz vs. stratigraphic unit top_K08-FA-204
Dz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
CKGR
KNGLM
RBSHM
ROCLT

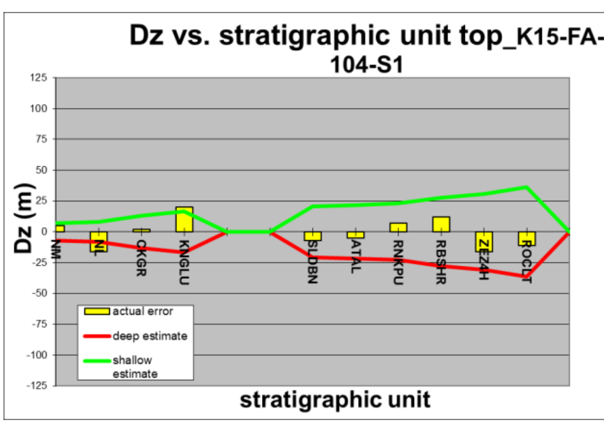

dDz vs. stratigraphic unit top_K08-FA-204
dDz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
180
-141
CKGR
KNGLM
RBSH
ROCLT

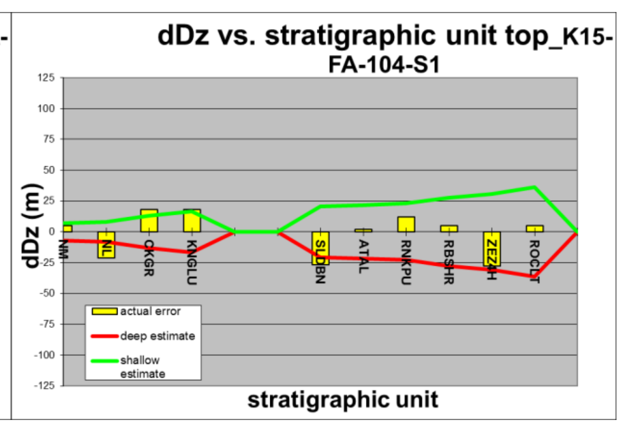

Dz vs. stratigraphic unit top_K07-10
Dz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
CKGR
KNGLU
RBSHM
ZEUC
ROCLT
DC

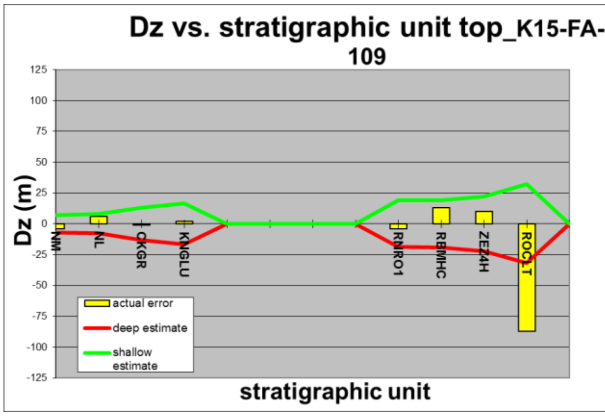

dDz vs. stratigraphic unit top_K07-10
dDz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
CKGR
KNGLU
RBSHM
ZEUC
ROCLT
DC

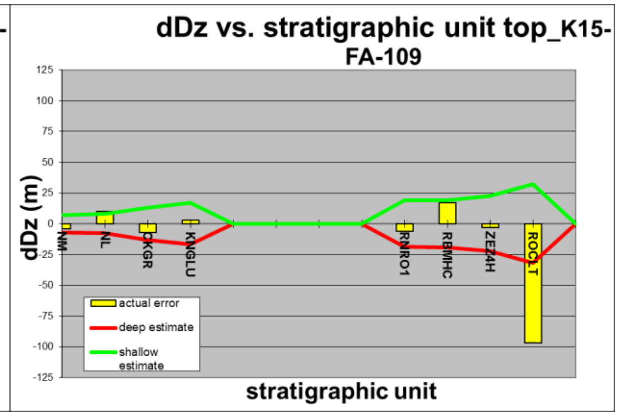

Dz vs. stratigraphic unit top_K15-11
Dz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
CK
KNGLU
RNKPD
RBMH
ZEUC
ROCLT
DC

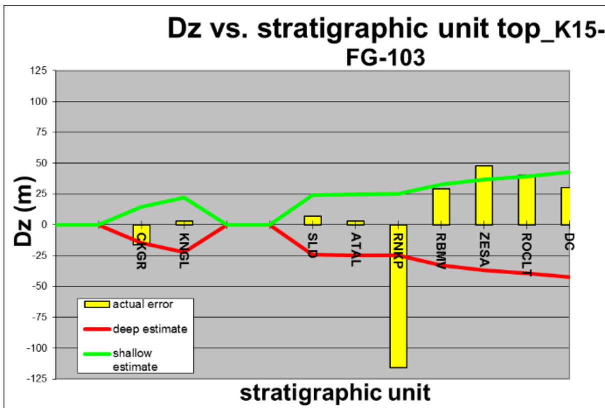

dDz vs. stratigraphic unit top_K15-11
dDz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
CK
KNGLU
RNKPD
RBMH
ZEUC
ROCLT
DC

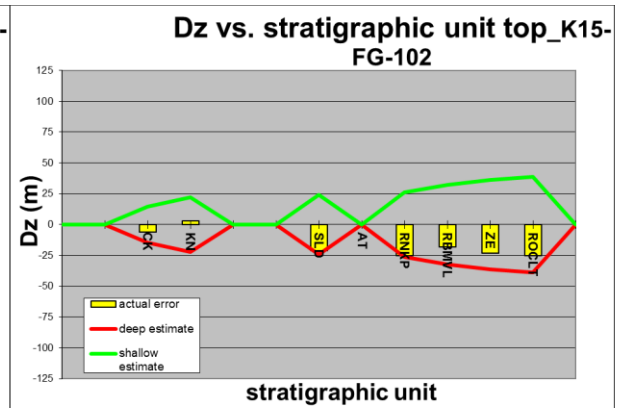

Dz vs. stratigraphic unit top_K15-FA-104-S1
Dz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
NM
NL
CKGR
KNGLU
SLDBN
ATAL
RNKPU
RBSHR
ZEZ4H
ROCLT

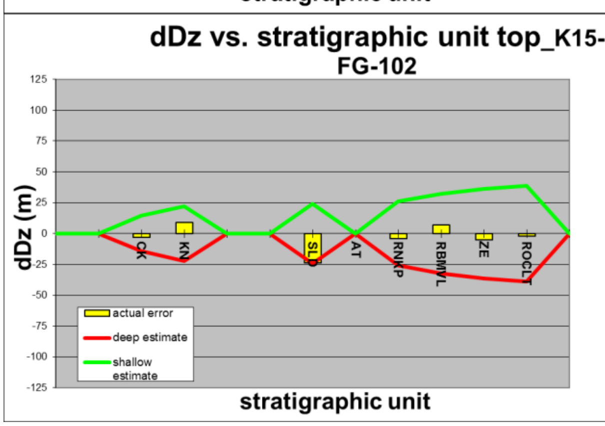

dDz vs. stratigraphic unit top_K15-FA-104-S1
dDz (m)
stratigraphic unit
actual error
deep estimate
shallow estimate
NM
NL
CKGR
KNGLU
SLDBN
ATAL
RNKPU
RBSHR
ZEZ4H
ROCLT

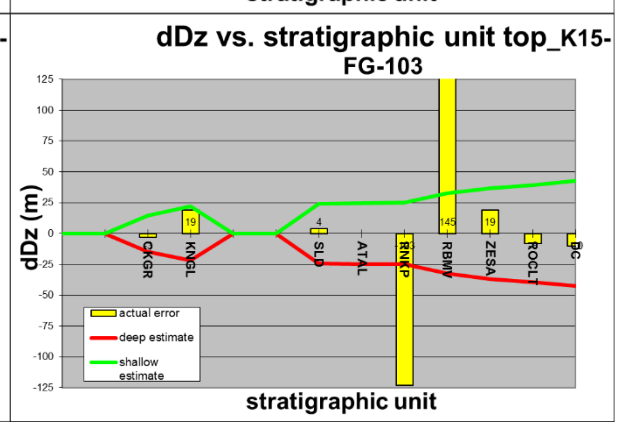

Dz vs. stratigraphic unit top_K15-FA-109
Dz (m)
stratigraphic unit
NM
NL
CKGR
KNGLU
RNRO1
RBMHC
ZEZ4H
ROCLT
actual error
deep estimate
shallow estimate

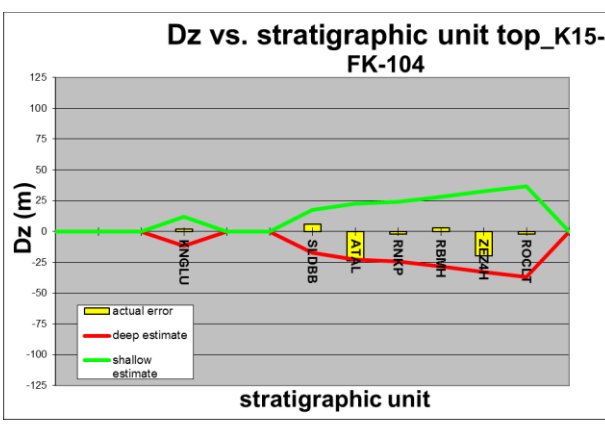

dDz vs. stratigraphic unit top_K15-FA-109
dDz (m)
stratigraphic unit
NM
NL
CKGR
KNGLU
RNRO1
RBMHC
ZEZ4H
ROCLT
actual error
deep estimate
shallow estimate

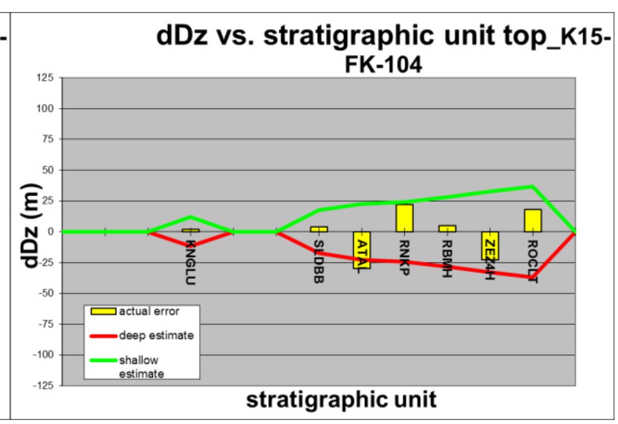

Dz vs. stratigraphic unit top_K15-FG-103
Dz (m)
stratigraphic unit
CKGR
KNGL
SLD
ATAL
RNKP
RBMY
ZESA
ROCLT
DC
actual error
deep estimate
shallow estimate

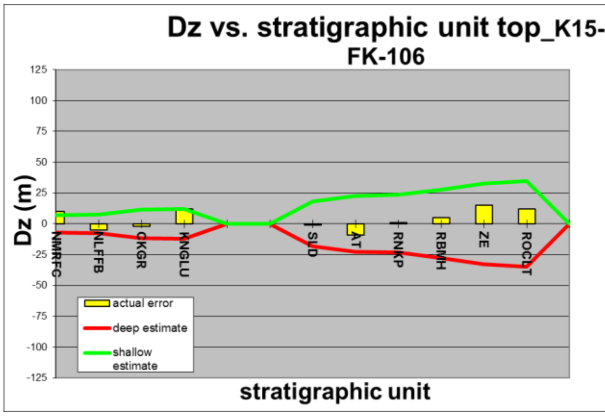

Dz vs. stratigraphic unit top_K15-FG-102
Dz (m)
stratigraphic unit
CK
KN
SLD
AT
RNKP
RBMYL
ZE
ROCLT
actual error
deep estimate
shallow estimate

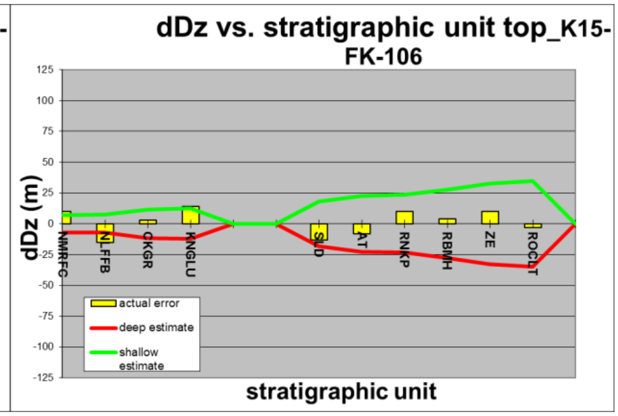

dDz vs. stratigraphic unit top_K15-FG-102
dDz (m)
stratigraphic unit
CK
KN
SLD
AT
RNKP
RBMYL
ZE
ROCLT
actual error
deep estimate
shallow estimate

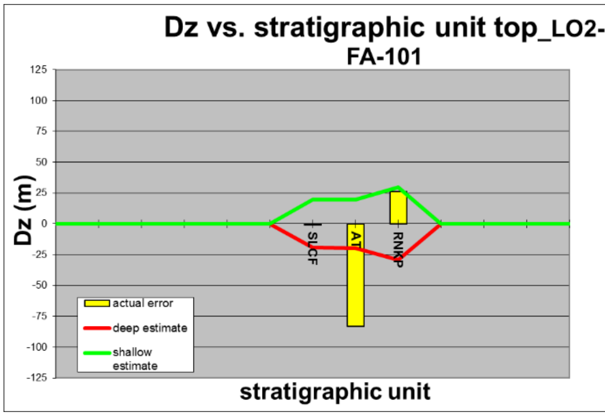

dDz vs. stratigraphic unit top_K15-FG-103
dDz (m)
stratigraphic unit
CKGR
KNGL
19
SLD
4
ATAL
RNKP
RBMY
145
ZESA
19
ROCLT
DC
actual error
deep estimate
shallow estimate

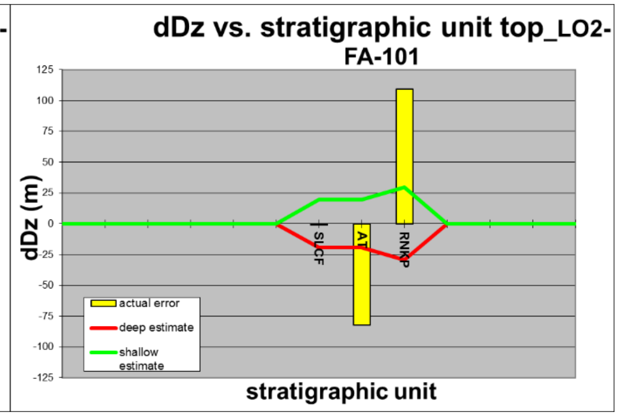

Dz vs. stratigraphic unit top_K15-FK-104
Dz (m)
stratigraphic unit
KNGLU
SLDBB
ATAL
RNKP
RBMH
ZEZ4H
ROCLT
actual error
deep estimate
shallow estimate

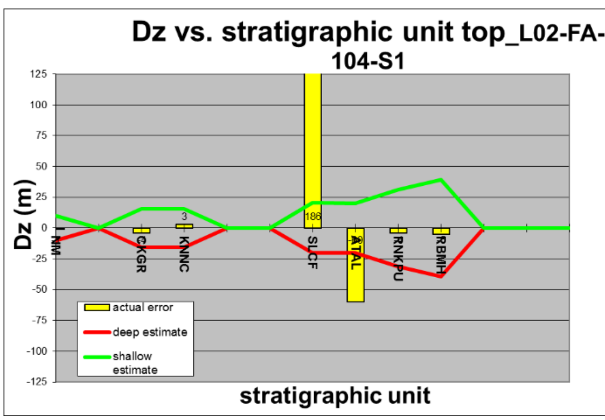

dDz vs. stratigraphic unit top_K15-FK-104
dDz (m)
stratigraphic unit
KNGLU
SLDBB
ATAL
RNKP
RBMH
ZEZ4H
ROCLT
actual error
deep estimate
shallow estimate

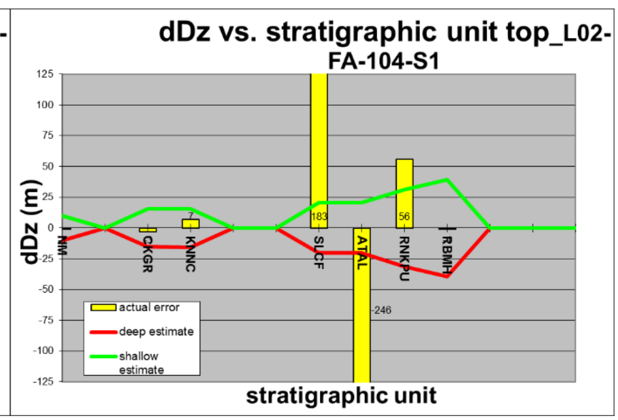

Dz vs. stratigraphic unit top_K15-FK-106
Dz (m)
stratigraphic unit
NMRFC NLFFB CKGR KNGLU SLD AT RNKP RBMH ZE ROCLT
actual error
deep estimate
shallow estimate

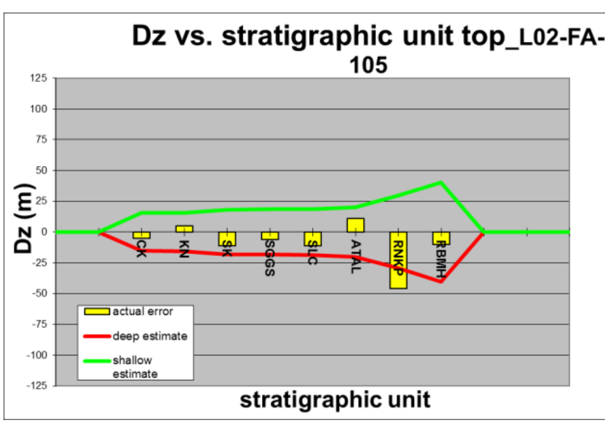

dDz vs. stratigraphic unit top_K15-FK-106
dDz (m)
stratigraphic unit
NMRFC NLFFB CKGR KNGLU SLD AT RNKP RBMH ZE ROCLT
actual error
deep estimate
shallow estimate

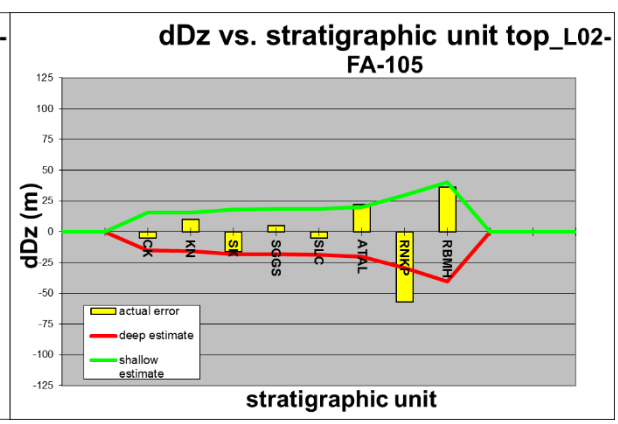

Dz vs. stratigraphic unit top_LO2-FA-101
Dz (m)
stratigraphic unit
SLCF AT RNKP
actual error
deep estimate
shallow estimate

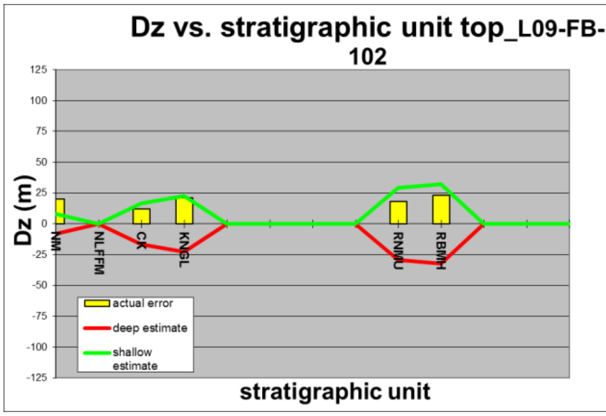

dDz vs. stratigraphic unit top_LO2-FA-101
dDz (m)
stratigraphic unit
SLCF AT RNKP
actual error
deep estimate
shallow estimate

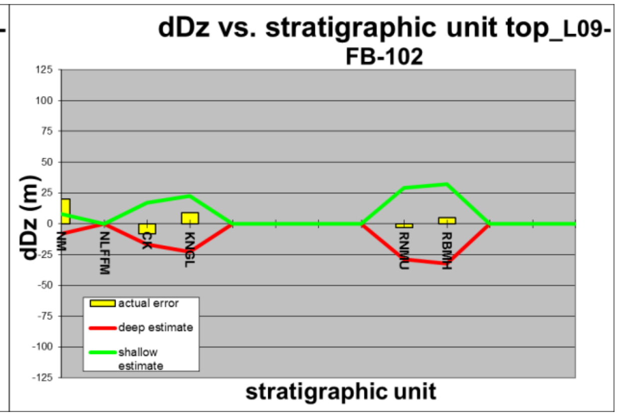

Dz vs. stratigraphic unit top_L02-FA-104-S1
Dz (m)
stratigraphic unit
NM CKGR KNNC SLCF ATAL RNKPU RBMH
3
186
actual error
deep estimate
shallow estimate

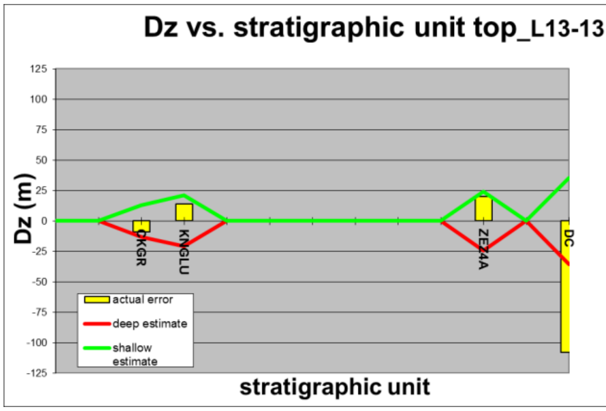

dDz vs. stratigraphic unit top_L02-FA-104-S1
dDz (m)
stratigraphic unit
NM CKGR KNNC SLCF ATAL RNKPU RBMH
7
183
56
-246
actual error
deep estimate
shallow estimate

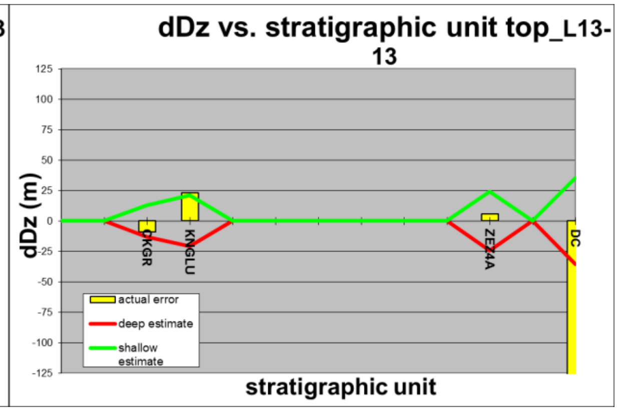

Dz vs. stratigraphic unit top_L02-FA-105
Dz (m)
stratigraphic unit
CK KN SK SGGS SLC ATAL RNKP RBMH
actual error
deep estimate
shallow estimate

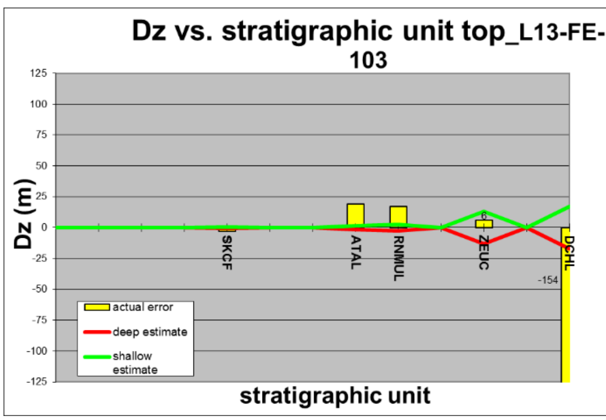

dDz vs. stratigraphic unit top_L02-FA-105
dDz (m)
stratigraphic unit
CK KN SK SGGS SLC ATAL RNKP RBMH
actual error
deep estimate
shallow estimate

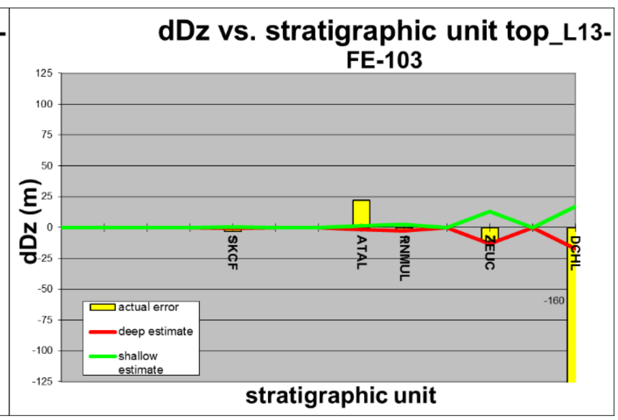

Dz vs. stratigraphic unit top_L09-FB-102
Dz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
NM
NLFFM
CK
KNGL
RNMU
RBMH
actual error
deep estimate
shallow estimate
stratigraphic unit

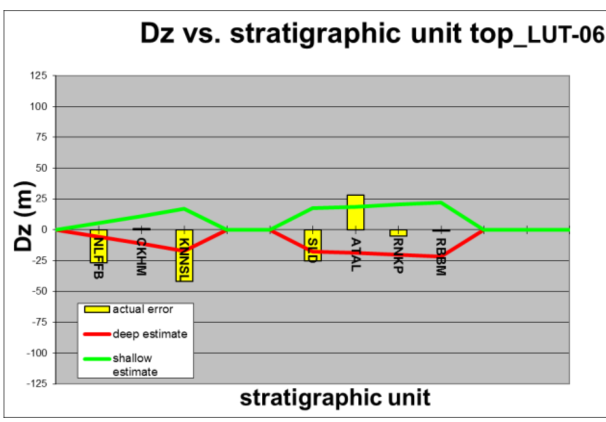

dDz vs. stratigraphic unit top_L09-FB-102
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
NM
NLFFM
CK
KNGL
RNMU
RBMH
actual error
deep estimate
shallow estimate
stratigraphic unit

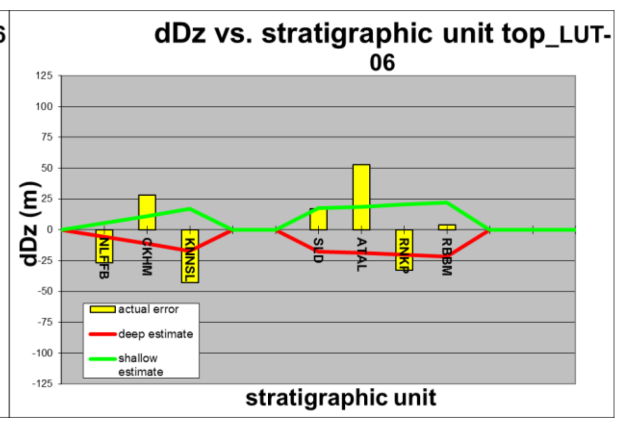

Dz vs. stratigraphic unit top_L13-13
Dz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
CKGR
KNGLU
ZEZ4A
DC
actual error
deep estimate
shallow estimate
stratigraphic unit

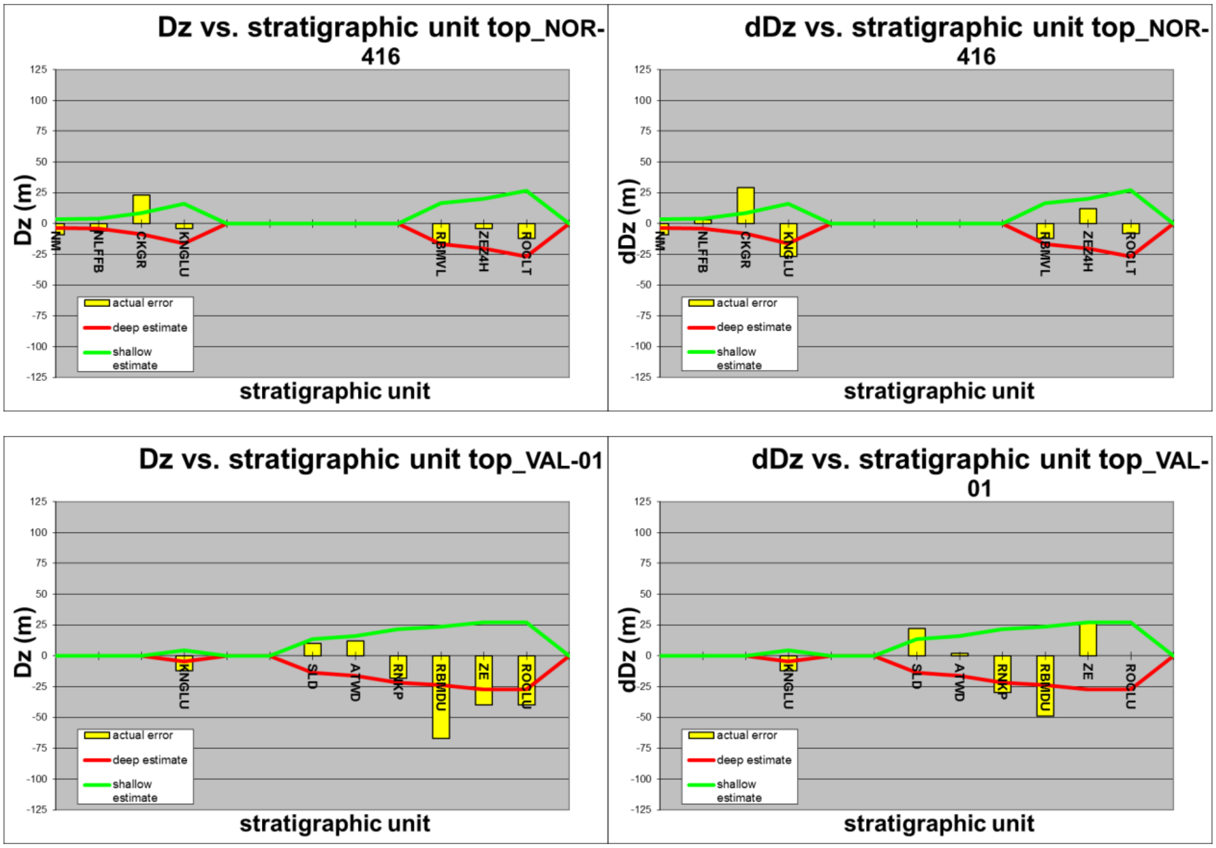

dDz vs. stratigraphic unit top_L13-13
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
CKGR
KNGLU
ZEZ4A
DC
actual error
deep estimate
shallow estimate
stratigraphic unit


Dz vs. stratigraphic unit top_L13-FE-103
Dz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
SKCF
ATAL
RNMUL
ZEUC
DCHL
-154
actual error
deep estimate
shallow estimate
stratigraphic unit


dDz vs. stratigraphic unit top_L13-FE-103
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
SKCF
ATAL
RNMUL
ZEUC
DCHL
-160
actual error
deep estimate
shallow estimate
stratigraphic unit


Dz vs. stratigraphic unit top_LUT-06
Dz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
NLFFB
CKHM
KNNSL
SLD
ATAL
RNKP
RBBM
actual error
deep estimate
shallow estimate
stratigraphic unit


dDz vs. stratigraphic unit top_LUT-06
dDz (m)
125
100
75
50
25
0
-25
-50
-75
-100
-125
NLFFB
CKHM
KNNSL
SLD
ATAL
RNKP
RBBM
actual error
deep estimate
shallow estimate
stratigraphic unit



2. Bar diagrams of T2Dcon errors for individual wells per structural element

This appendix contains the graphs of the relative Dz and dDz T2Dcon errors for individual wells for the structural elements: Platform (Cleaverbank Platform), Minor High (Cleaver Bank High), Minor Basin (Terschelling Basin and Vlieland Basin), Main Basin (Broad Fourteens Basin and West Netherlands Basin) and Dutch Central Graben (DCG). Bars of identical wells are displayed in the same color. Black, solid lines are the positive and negative values of the deviation: 1% of prognosed well top depth. The same color coding for the wells has been applied in all the graphs in this appendix section.

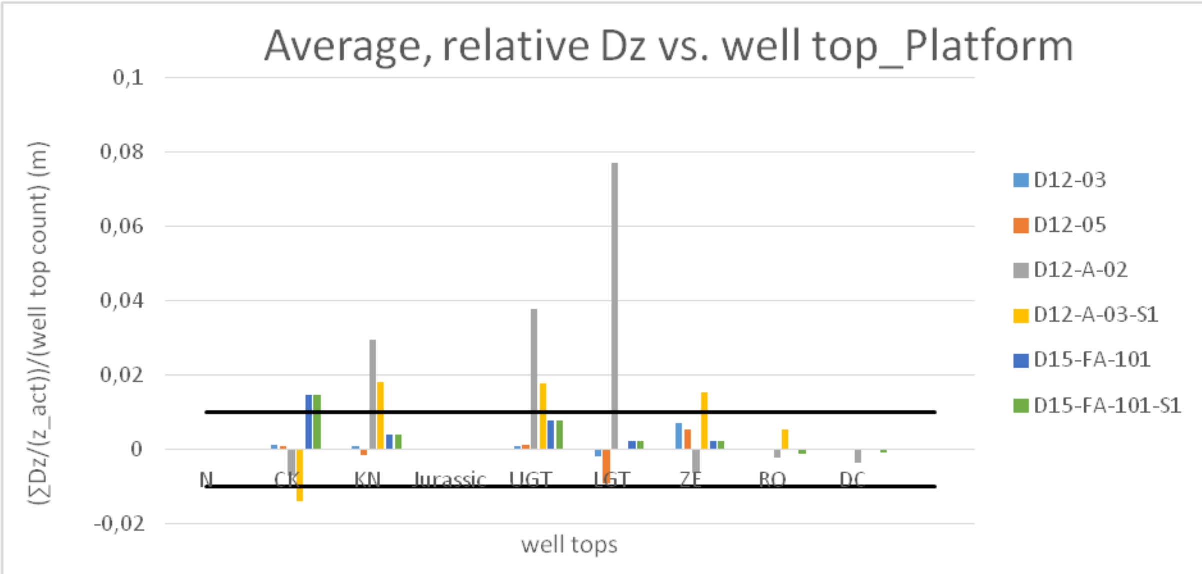


Figure 50 - Relative Dz vs. well top for individual wells in the structural element Platform. D12-A-02 has largest T2Dcon errors, in particular for top LGT. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (page 18) for a discussion of the diagram.

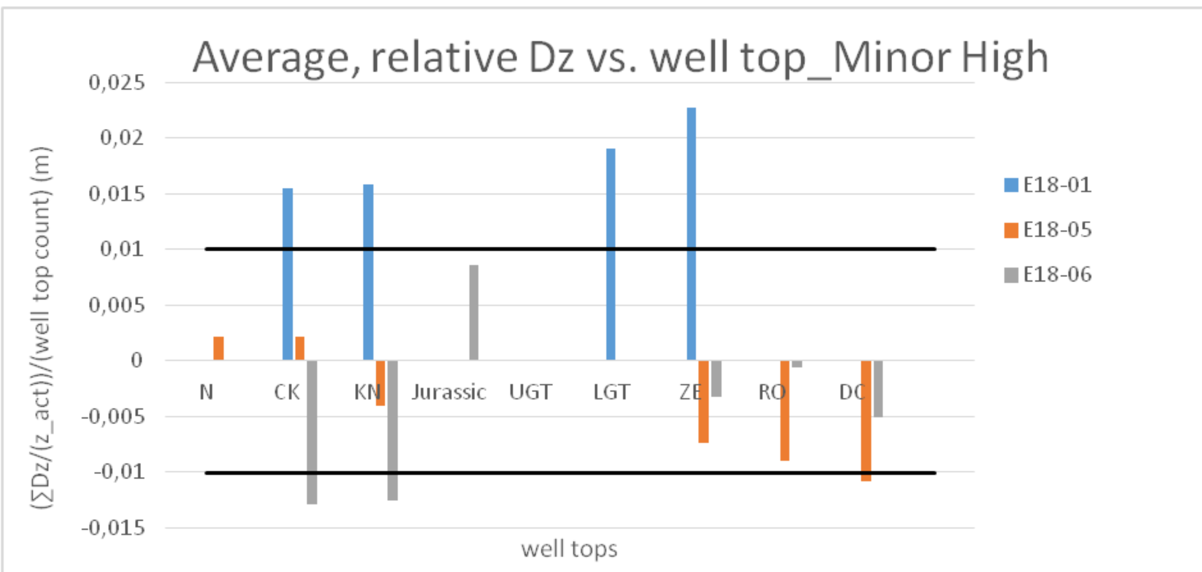


Figure 51 - Relative Dz vs. well top for individual wells in the structural element High. All three wells have T2Dcon errors outside the acceptable deviation range. CK and KN yield large T2Dcon errors most consistently. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (page 18) for a discussion of the diagram.

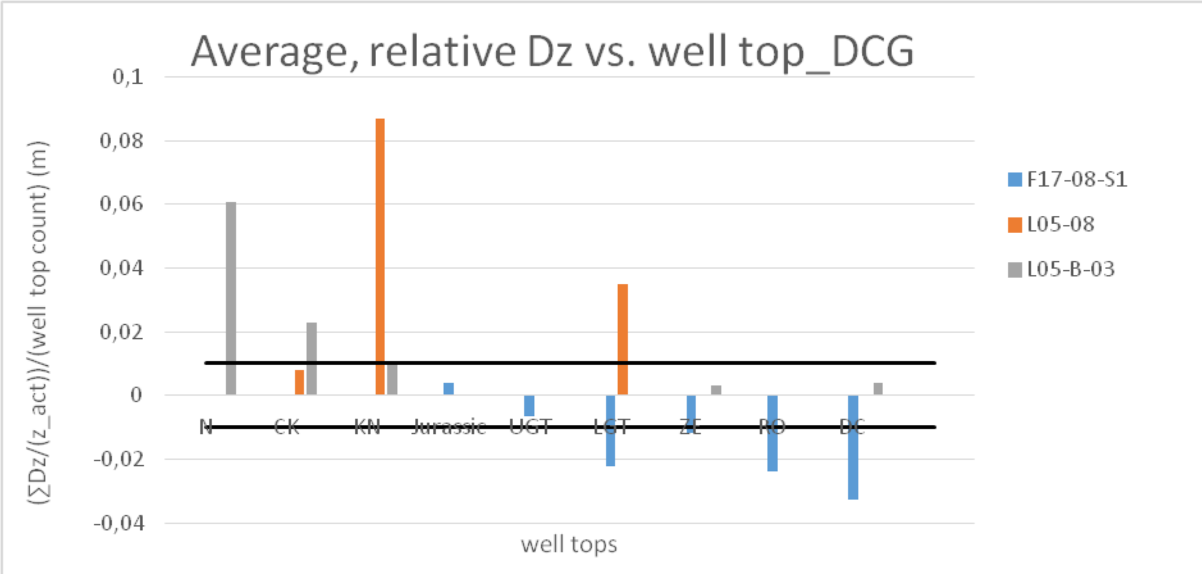


Figure 52 - Relative Dz vs. well top for individual wells in the Dutch Central Graben. All three wells have T2Dcon errors outside the acceptable deviation range. Large T2Dcon errors exist for the southern edge of the DCG (L05-08 and L05-B-03), relative to the center (F17-08-S1). For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (page 18) for a discussion of the diagram.

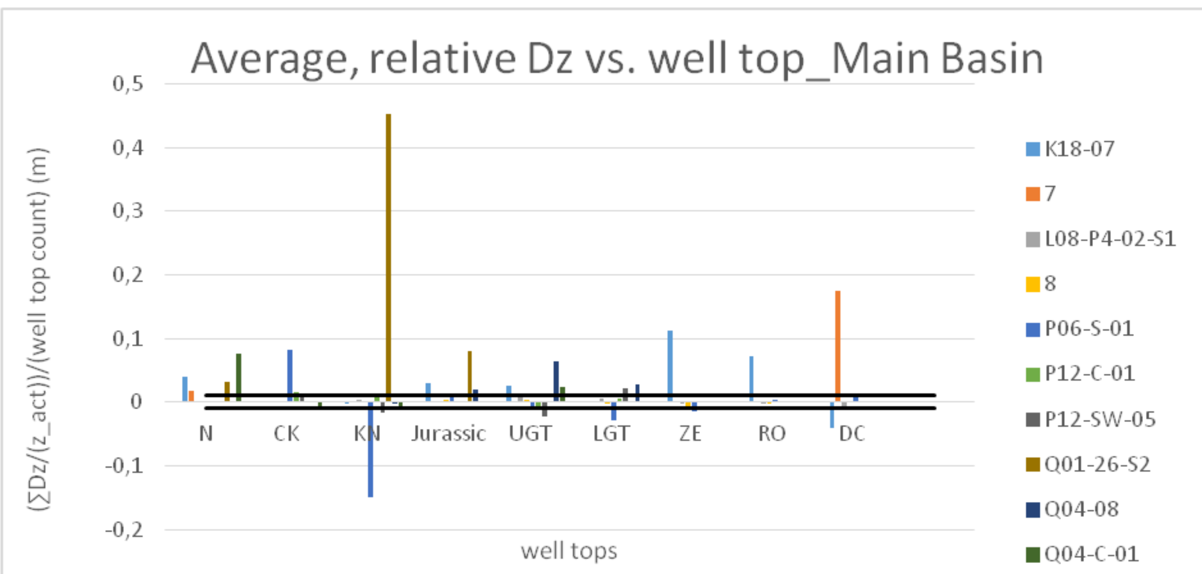


Figure 53 - Relative Dz vs. well top for individual wells in the structural element Main Basin. Wells Q04-C-01, 7, K18-09, P06-S-01, Q04-08 and Q01-26-S2 have T2Dcon errors outside the acceptable deviation range. The largest and most consistent errors exist for top KN. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (page 18) for a discussion of the diagram.

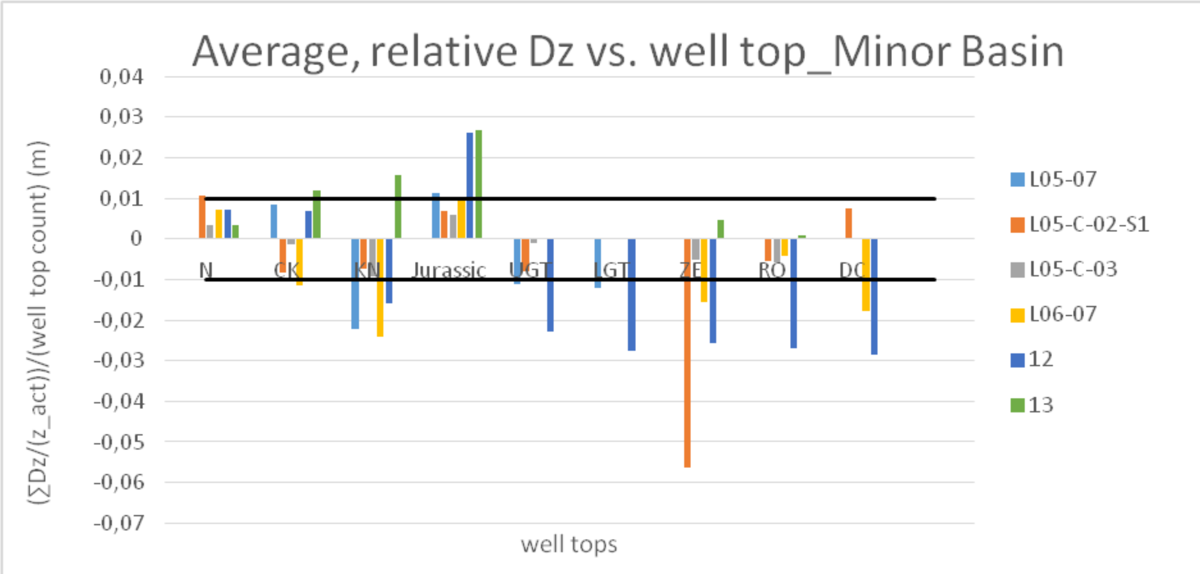


Figure 54 - Relative Dz vs. well top for individual wells in the structural element Minor Basin. All wells have T2Dcon errors outside the acceptable deviation range. Top KN, Jurassic and ZE have largest and most consistent errors. L06-07 and 13 most consistently have large errors for stratigraphically shallow well tops. Well 12 most consistently has large errors for stratigraphically deep well tops. L05-C-02-S1 has main T2Dcon errors for top ZE. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (page 18) for a discussion of the diagram.

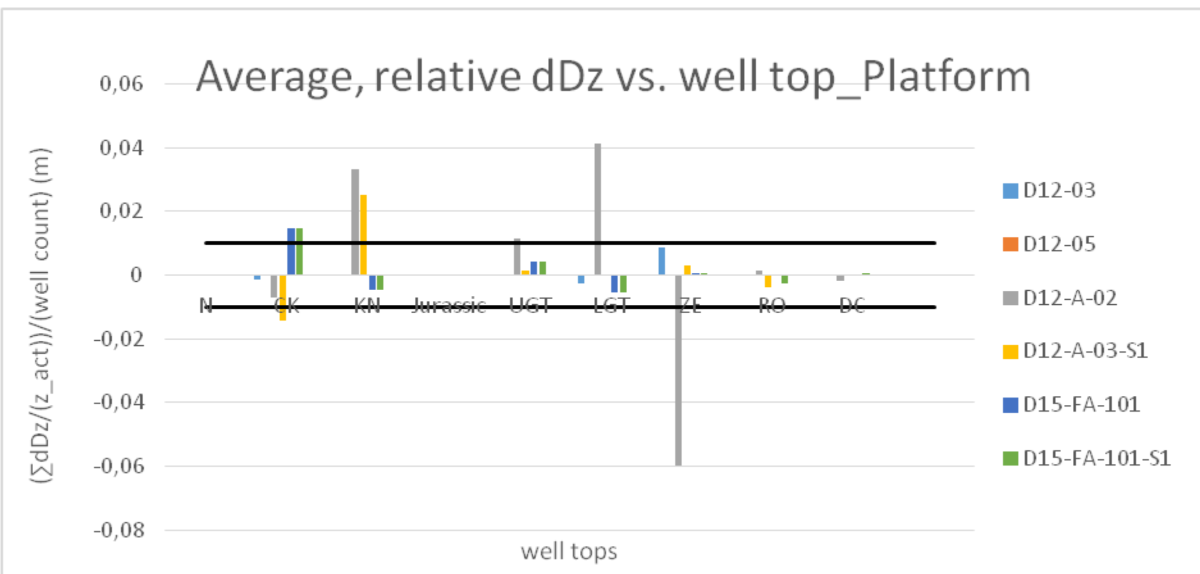


Figure 55 - Relative dDz vs. well top for individual wells in the structural element platform. D12-A-02 in particular has large T2Dcon errors. For D12-A-02: top LGT Dz decreases, while top ZE dDz as a result increases. Top UGT dDz for the wells is decreased relative to Dz. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (page 18) for a discussion of the diagram.

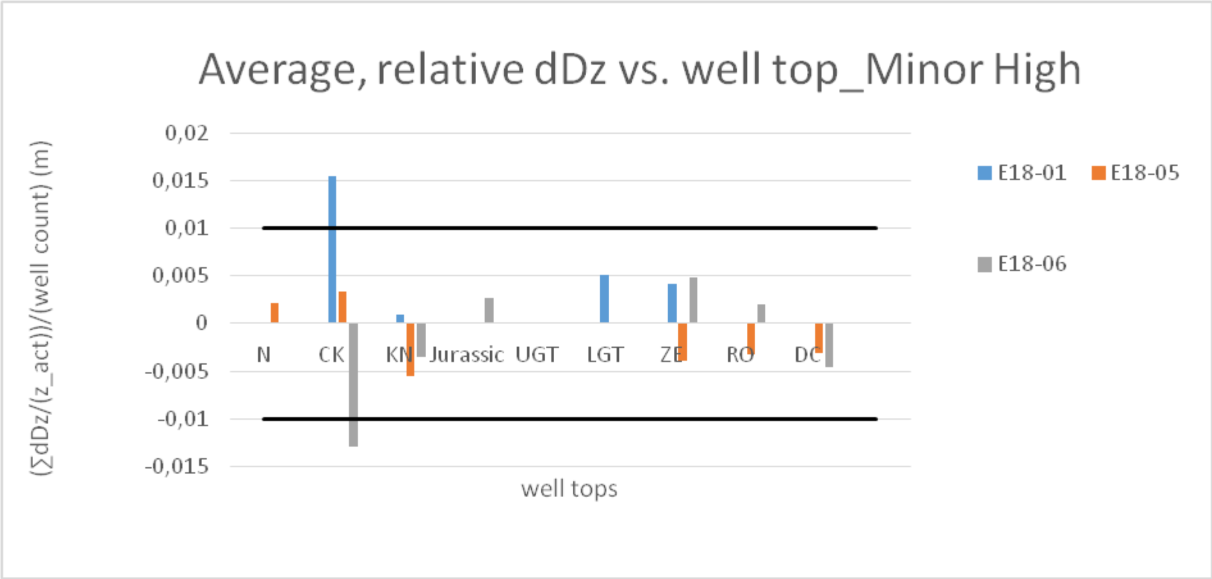


Figure 56 - Relative dDz vs. well top for individual wells in the structural element High. dDz T2Dcon errors are often consistently smaller for all wells compared to Dz. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (page 18) for a discussion of the diagram.

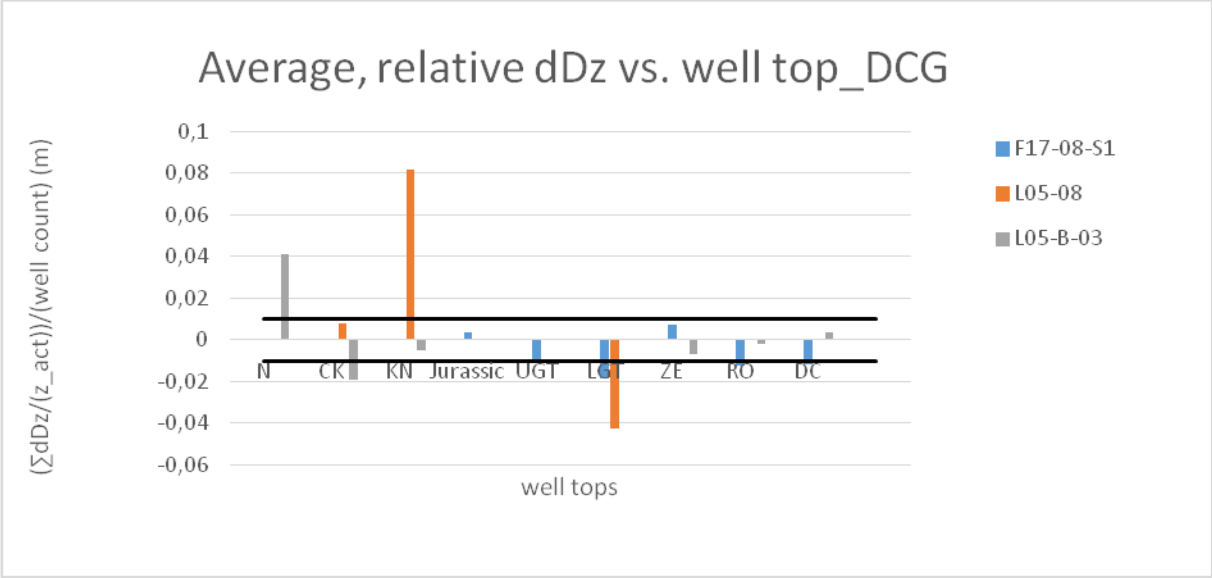


Figure 57- Relative dDz vs. well top for individual wells in the Dutch Central Graben. dDz T2Dcon errors are often equal or smaller for all wells compared to Dz. Relative dDz T2Dcon errors for F17-08-S1 are smaller than its relative Dz T2Dcon errors. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (page 18) for a discussion of the diagram.

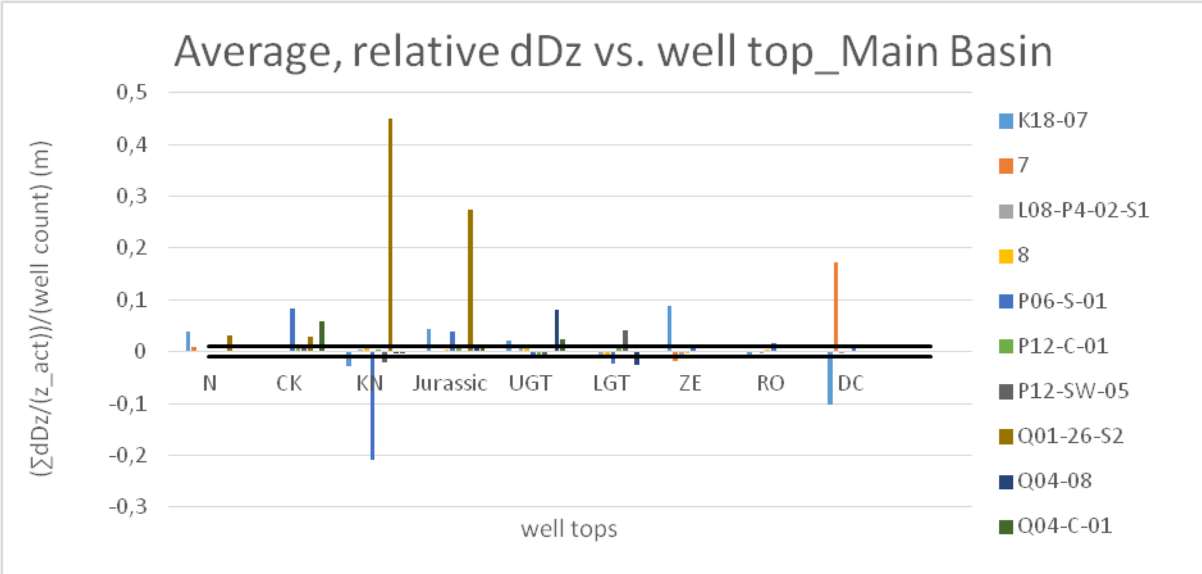


Figure 58 - Relative dDz vs. well top for individual wells in the structural element platform Main Basin. dDz T2Dcon errors of top CK, Jurassic are increased compared to Dz. dDz T2Dcon errors of deeper well tops (RO and DC) are decreased compared to Dz. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (page 18) for a discussion of the diagram.

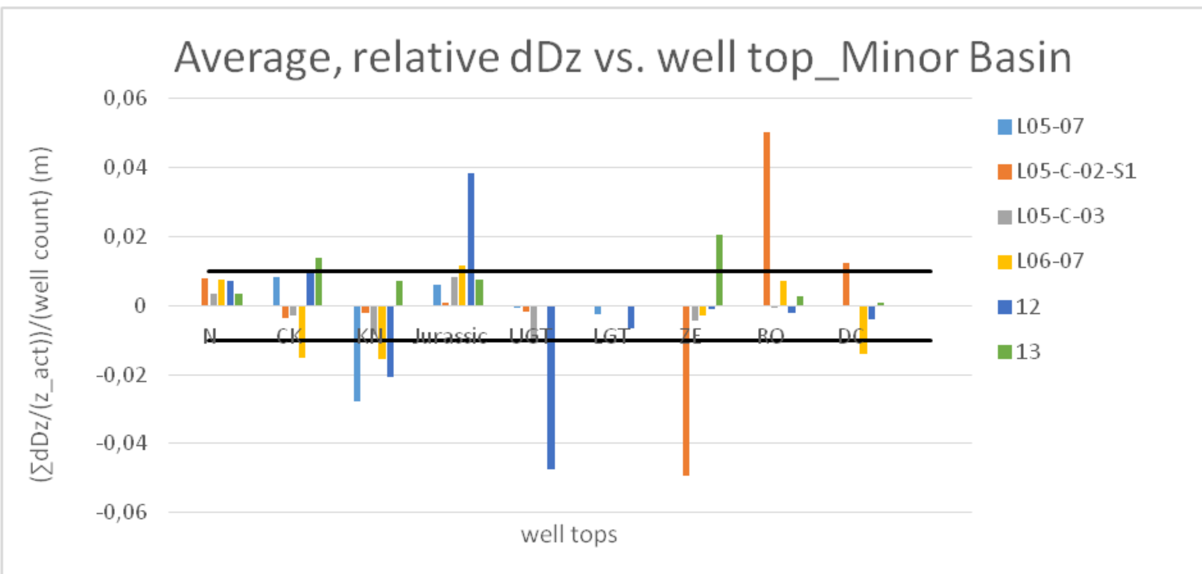


Figure 59 - Relative dDz vs. well top for individual wells in the structural element platform Minor Basin. dDz T2Dcon errors of top Jurassic and DC have consistently decreased for all wells compared to Dz. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (page 18) for a discussion of the diagram.

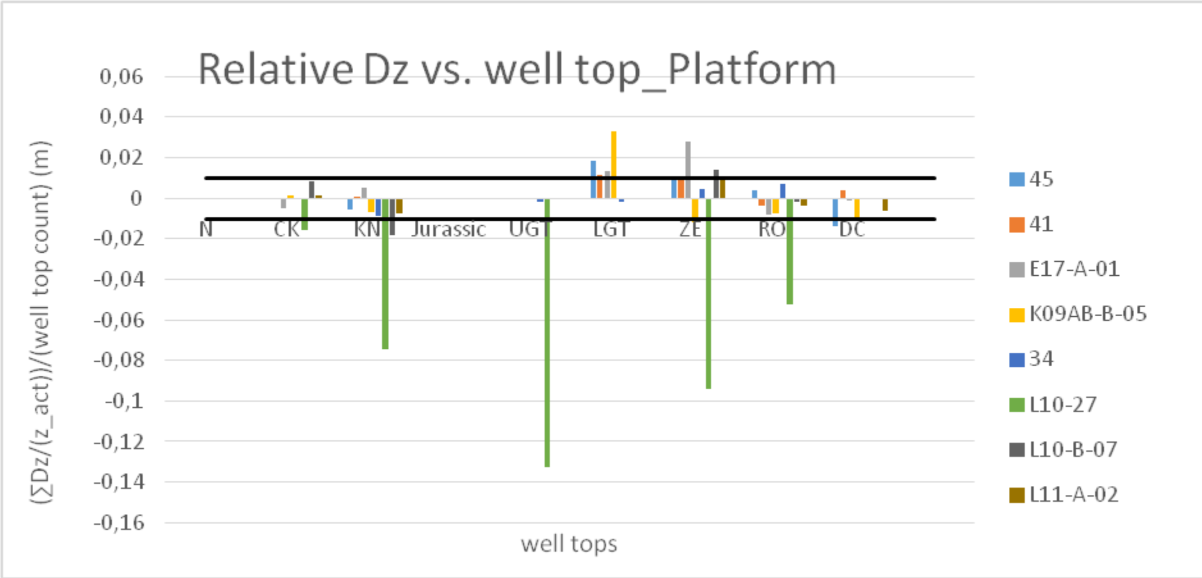


Figure 60 - Relative Dz vs. well top for individual wells in the structural element Platform. L10-27 has largest significant T2Dcon errors, these are all negative. Positive top LGT and ZE T2Dcon errors exist for most wells (top ZE for L10-27 is negative). For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. For top North Sea Group and top Jurassic values of individual wells are absolute averages. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 30) for a discussion of the diagram.

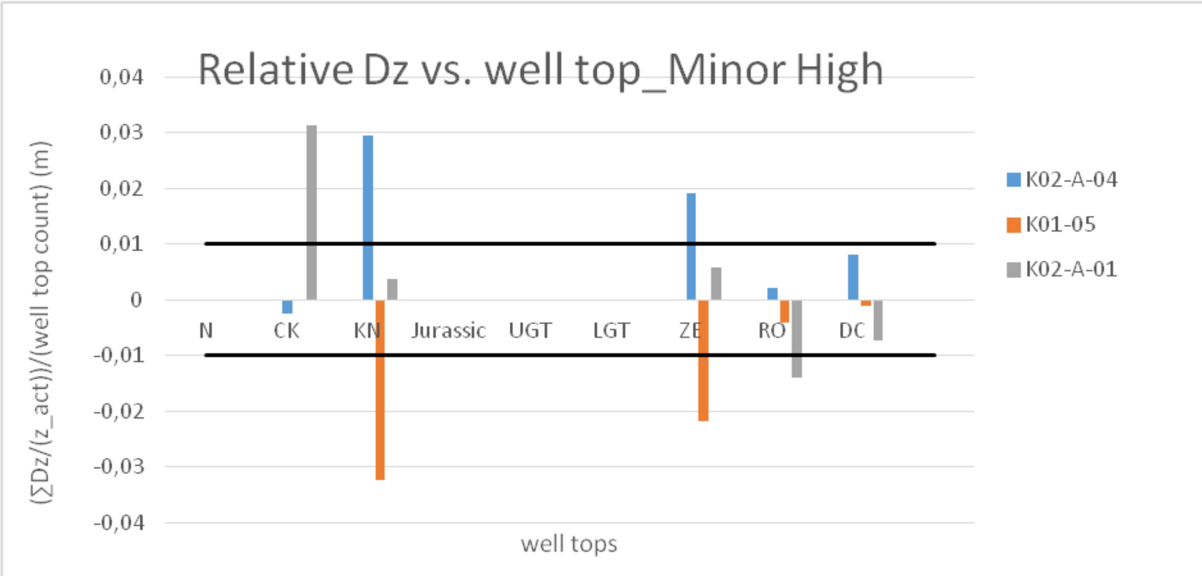


Figure 61 - Relative Dz vs. well top for individual wells in the structural element Minor High. All three wells have T2Dcon errors outside the acceptable deviation range. Largest significant T2Dcon errors are for top KN and ZE. K01-05 consistently yields negative T2Dcon errors, whereas K02-A-04 and K02-A-01 yield positive T2Dcon errors (with the exception of top RO and DC for K02-A-01). For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 30) for a discussion of the diagram.

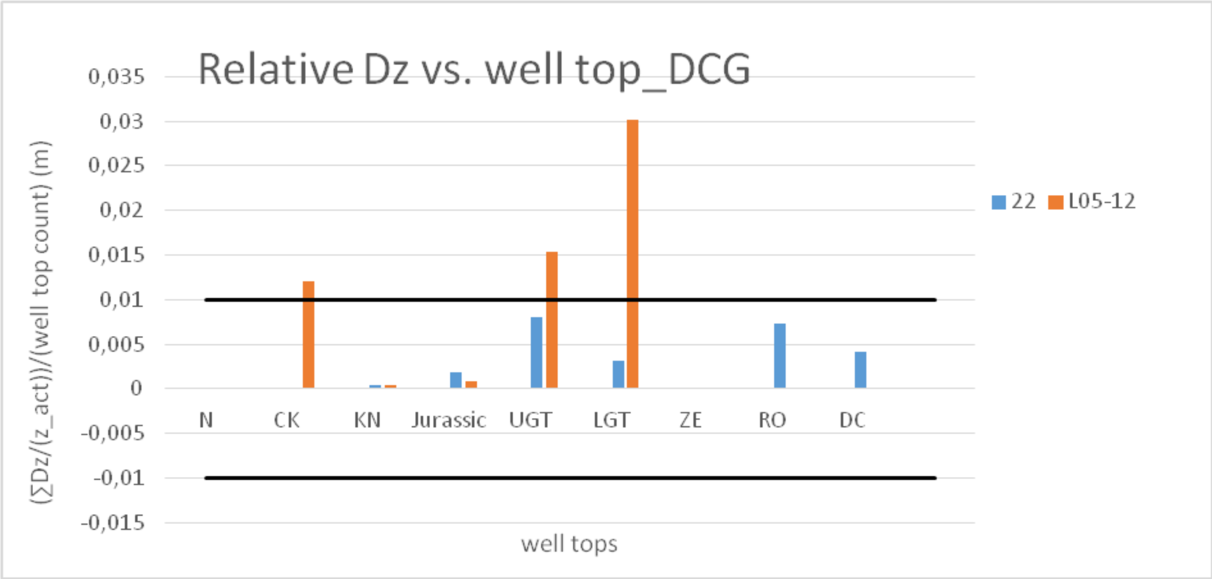


Figure 62 - Relative Dz vs. well top for individual wells in the Dutch Central Graben. L05-12 has T2Dcon errors outside the acceptable deviation range. Significant T2Dcon errors are encountered in Triassic formations. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 30) for a discussion of the diagram.

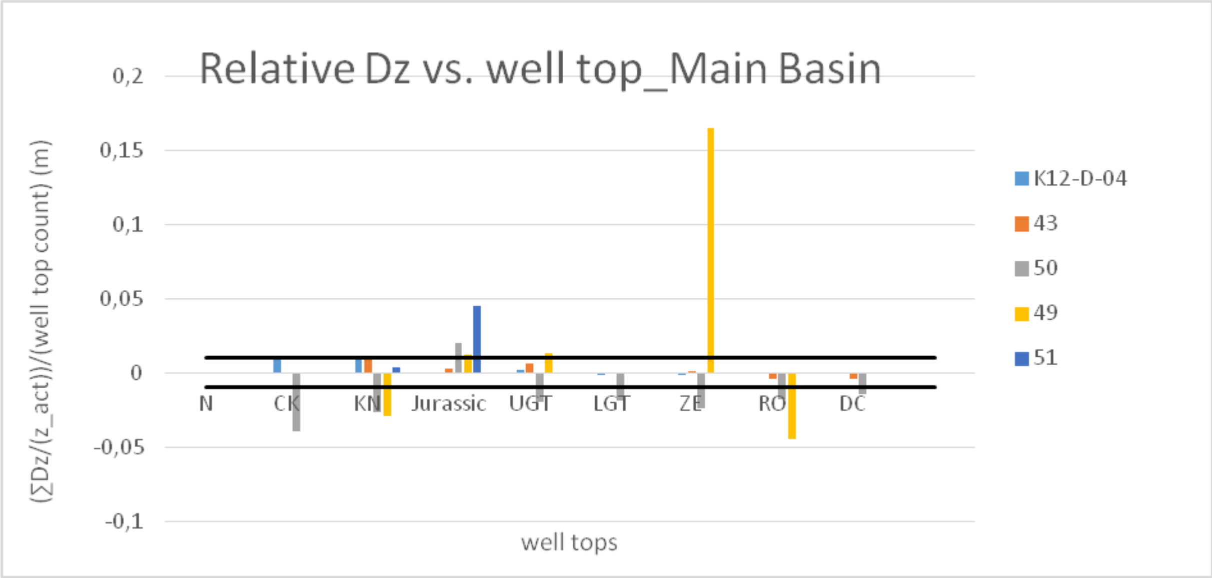


Figure 63 - Relative Dz vs. well top for individual wells in the structural element Main Basin. Significant T2Dcon errors are most often encountered for top KN, Jurassic and ZE. Well 50 fairly consistently has T2Dcon errors deep to prognosis (negative). For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 30) for a discussion of the diagram.

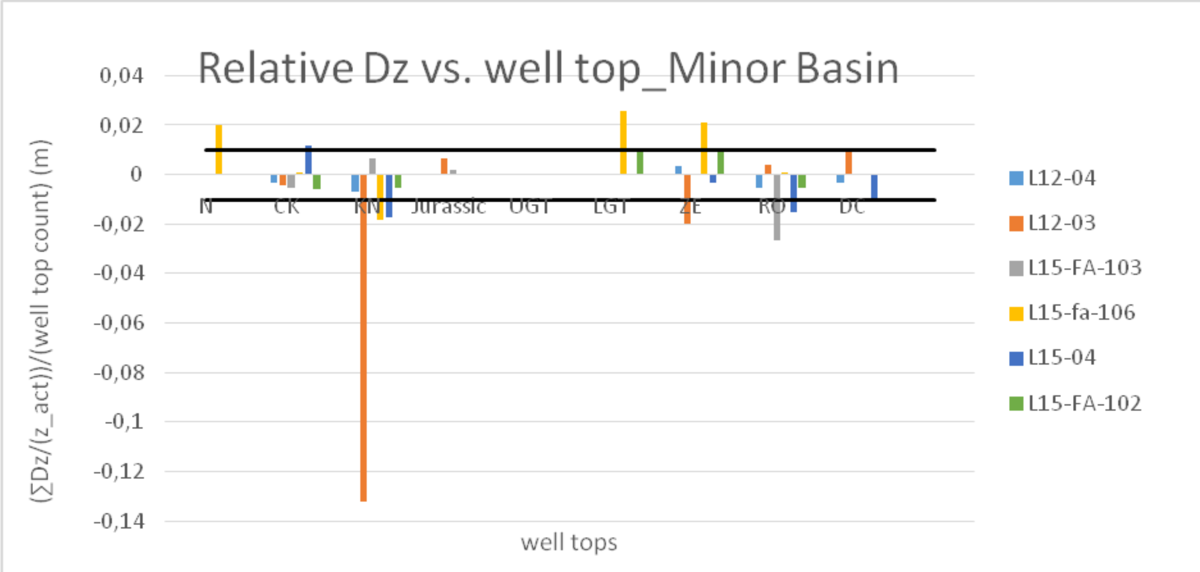


Figure 64 - Relative Dz vs. well top for individual wells in the structural element Minor Basin. Most significant T2Dcon errors are encountered for top KN and ZE. L12-03 has largest significant T2Dcon errors (for KN). For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 30) for a discussion of the diagram.

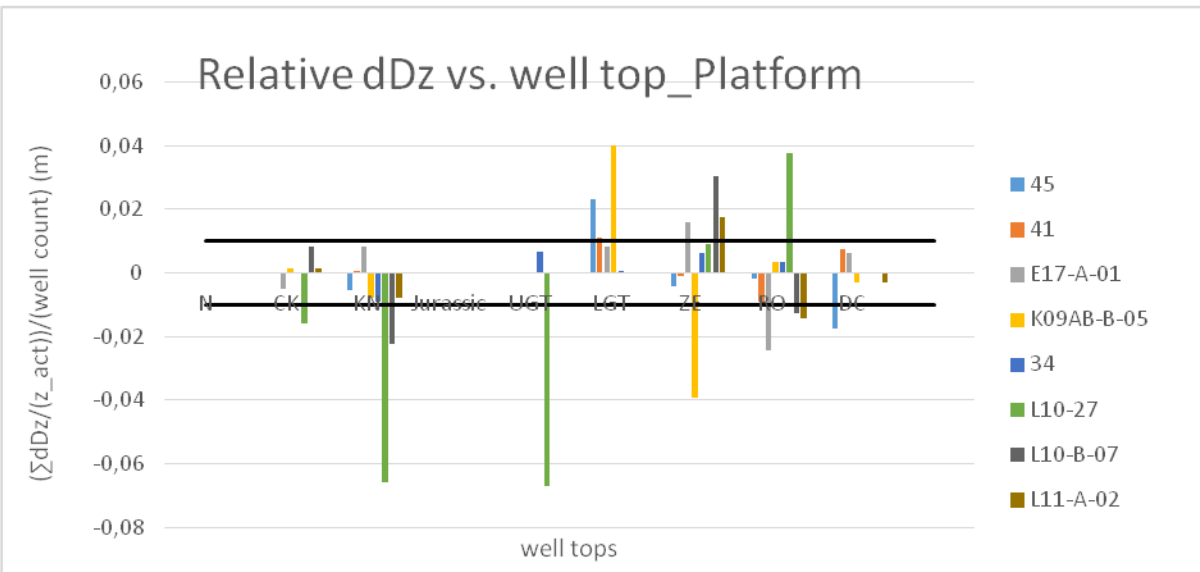


Figure 65 - Relative dDz vs. well top for individual wells in the structural element Platform. L10-27 dDz T2Dcon errors are slightly decreased compared to Dz. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 30) for a discussion of the diagram.

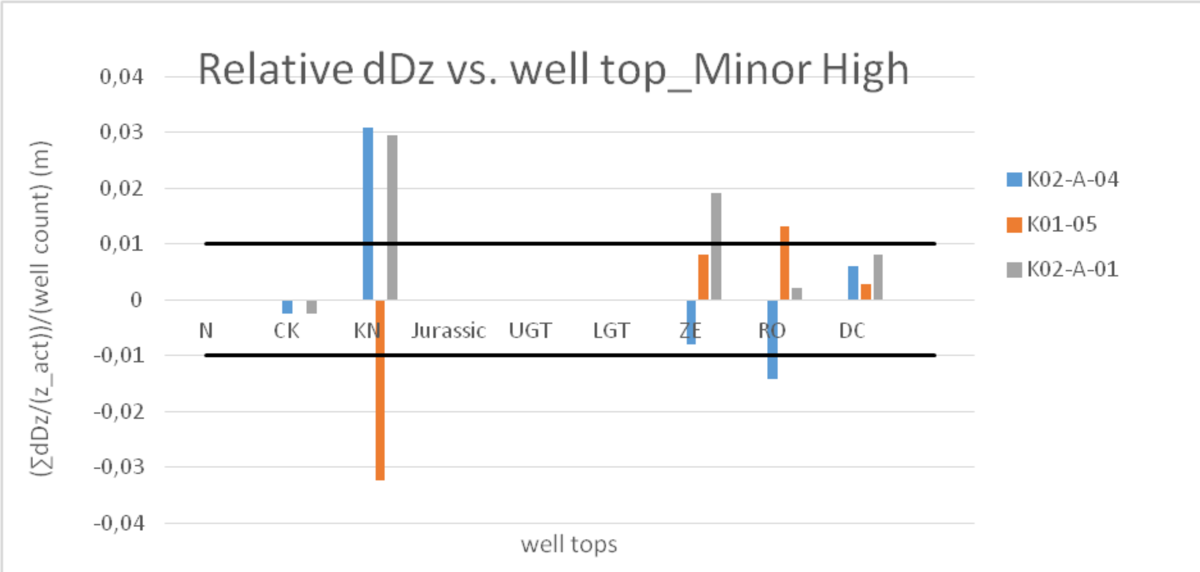


Figure 66 - Relative dDz vs. well top for individual wells in the structural element Minor High. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average valuesSee appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 30) for a discussion of the diagram.

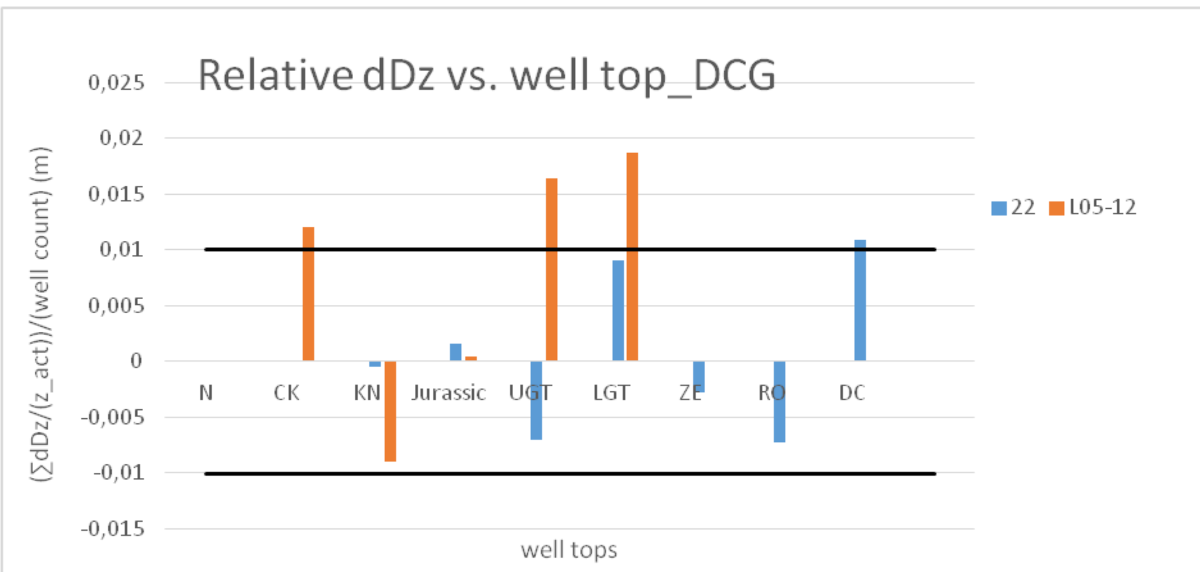


Figure 67 - Relative dDz vs. well top for individual wells in the Dutch Central Graben. dDz T2Dcon errors in Triassic formations for L05-12 are lower than Dz. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 30) for a discussion of the diagram.

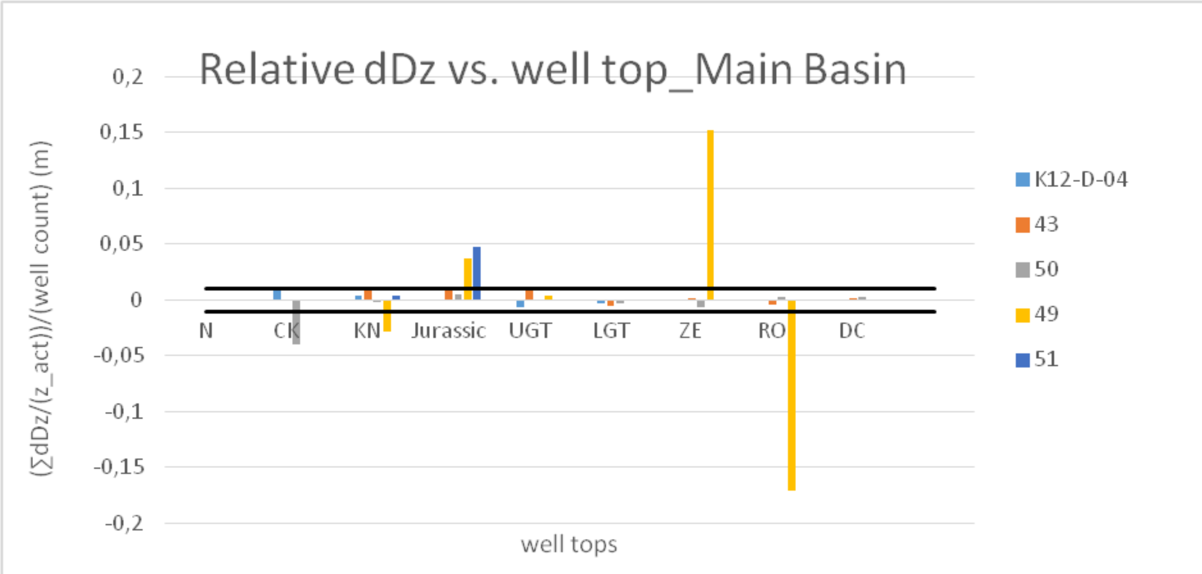


Figure 68 - Relative dDz vs. well top for individual wells in the structural element Main Basin. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 30) for a discussion of the diagram.

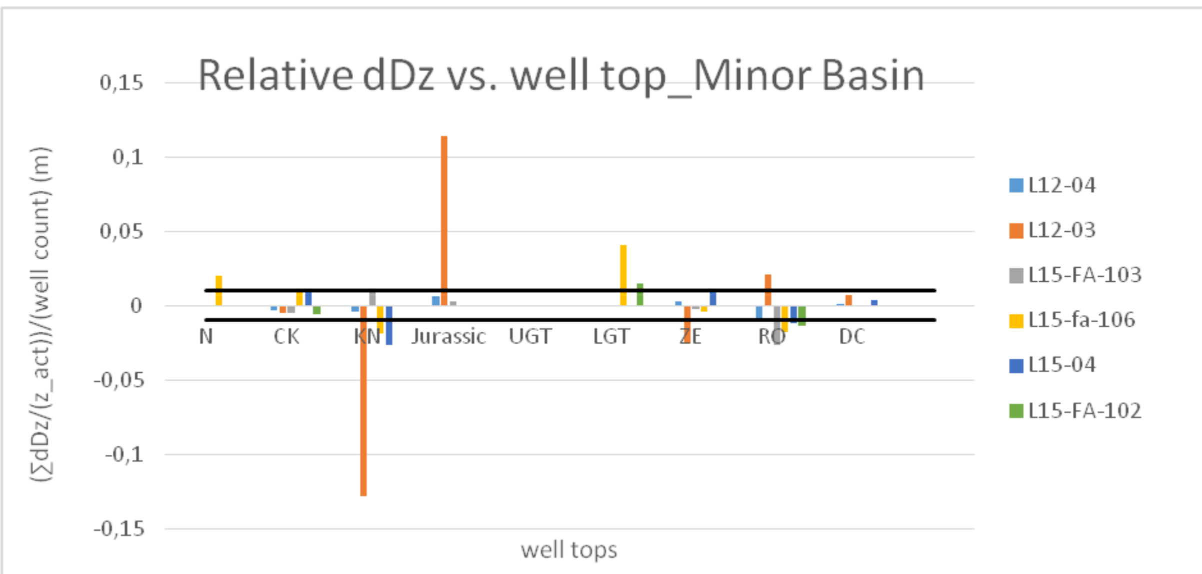


Figure 69 - Relative dDz vs. well top for individual wells in the structural element Minor Basin. L12-03 has significant dDz T2Dcon error for top Jurassic. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 30) for a discussion of the diagram.

NAM

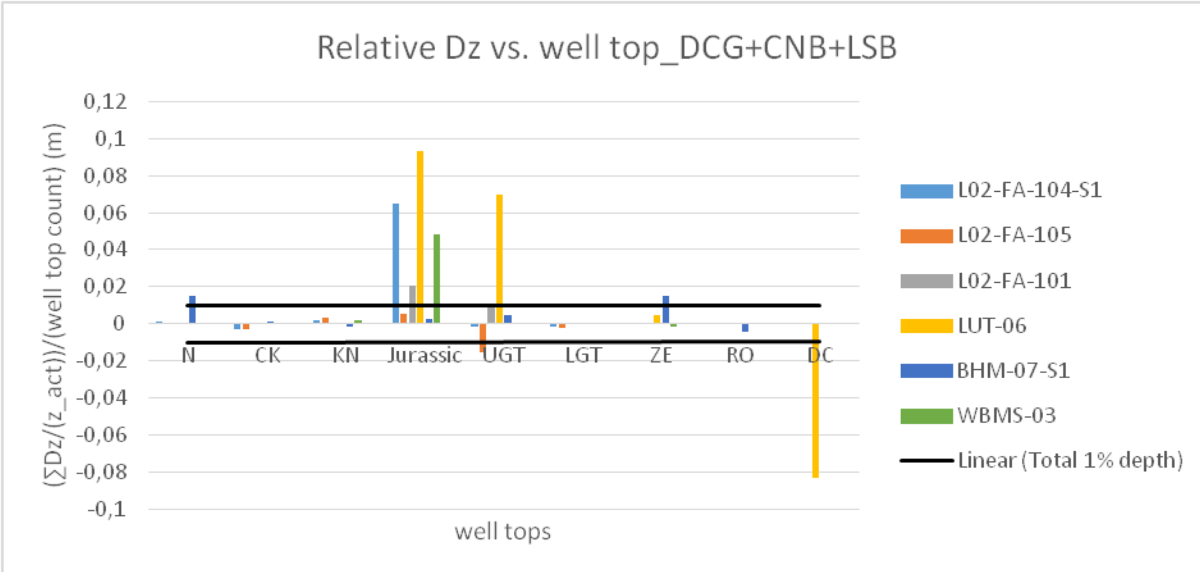


Figure 70 - Average, relative Dz vs. well top for individual wells in the structural element DCG+CNB+LSB. For top North Sea Group and top Jurassic values of individual wells are absolute averages. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 39-40) for a discussion of the diagram.

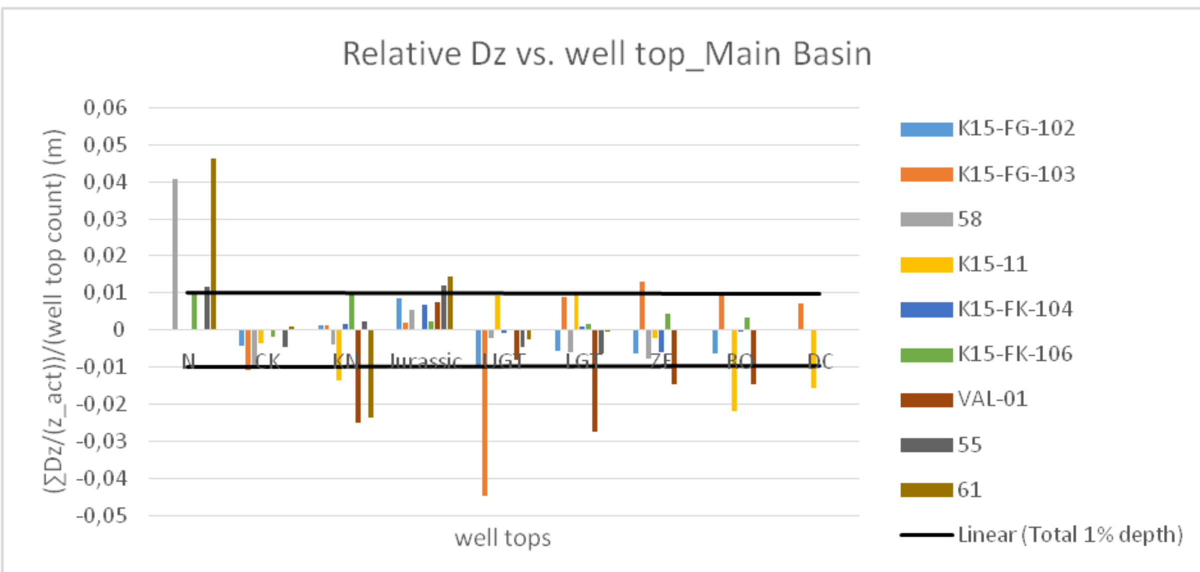


Figure 71 - Average, relative Dz vs. well top for individual wells in the structural element Main Basin. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 39-40) for a discussion of the diagram.

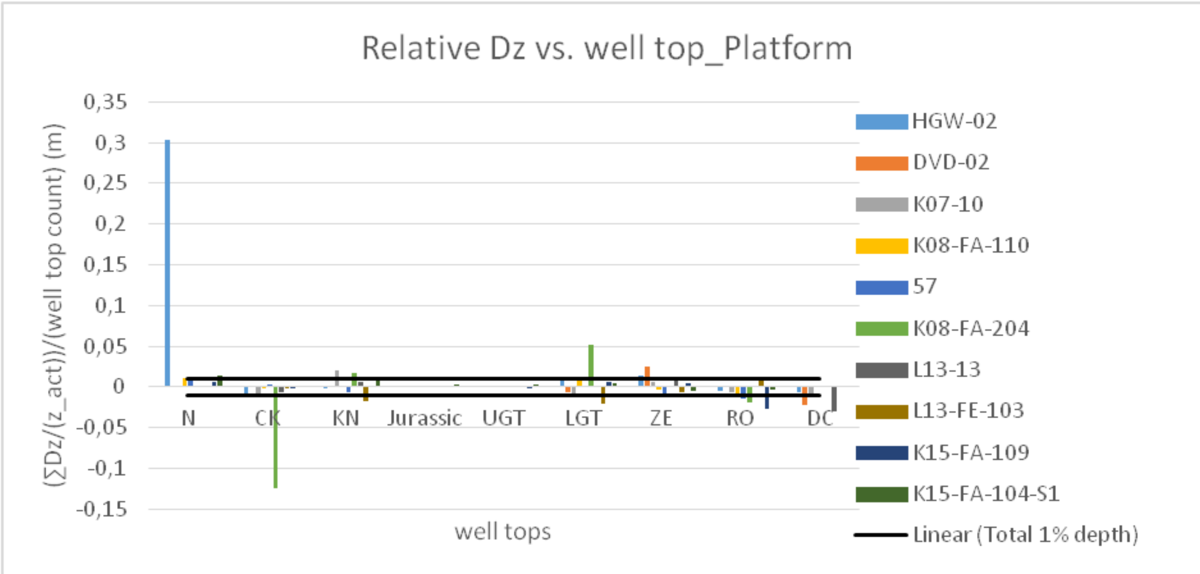


Figure 72 - Average, relative Dz vs. well top for individual wells in the structural element Platform. Note difference in scale of y-axis. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 39-40) for a discussion of the diagram.

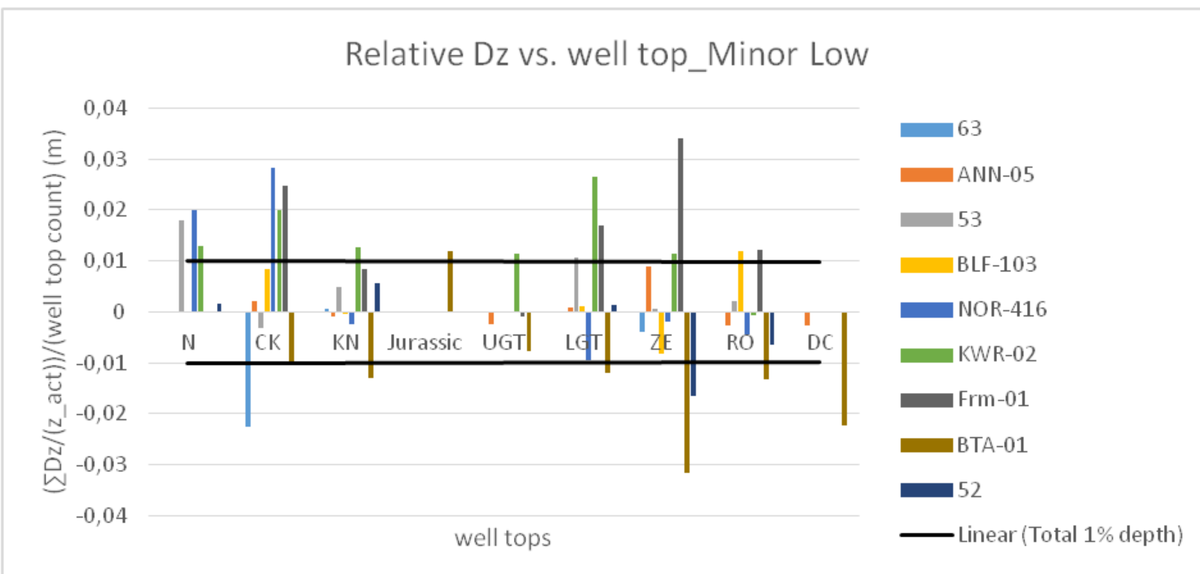


Figure 73 - Average, relative Dz vs. well top for individual wells in the structural element Minor Low. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 39-40) for a discussion of the diagram.

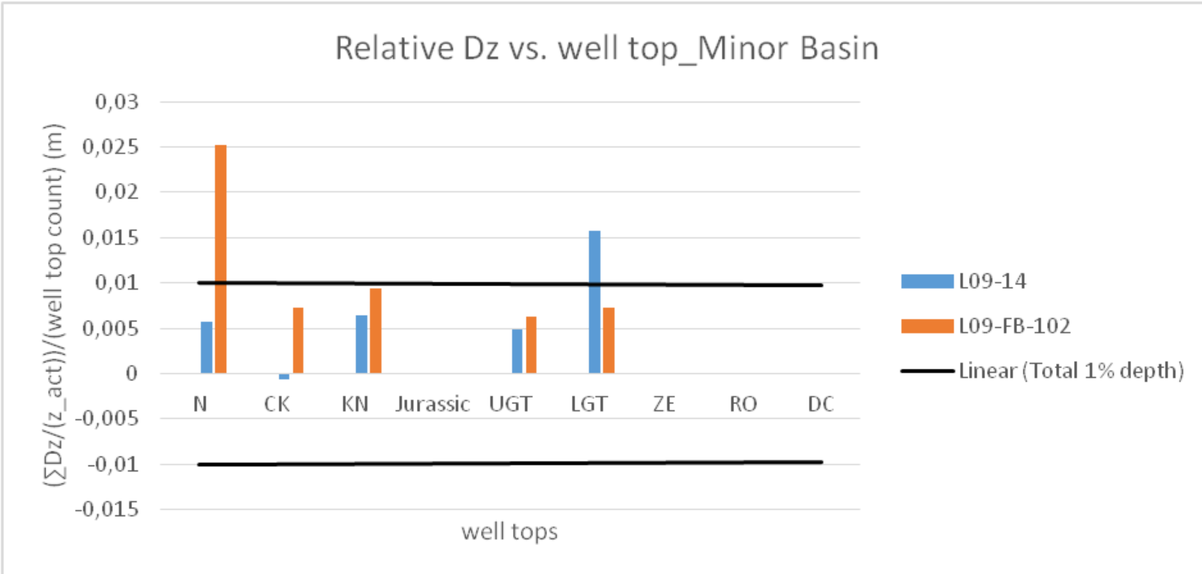


Figure 74 - Average, relative Dz vs. well top for individual wells in the structural element Minor Basin. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 39-40) for a discussion of the diagram.

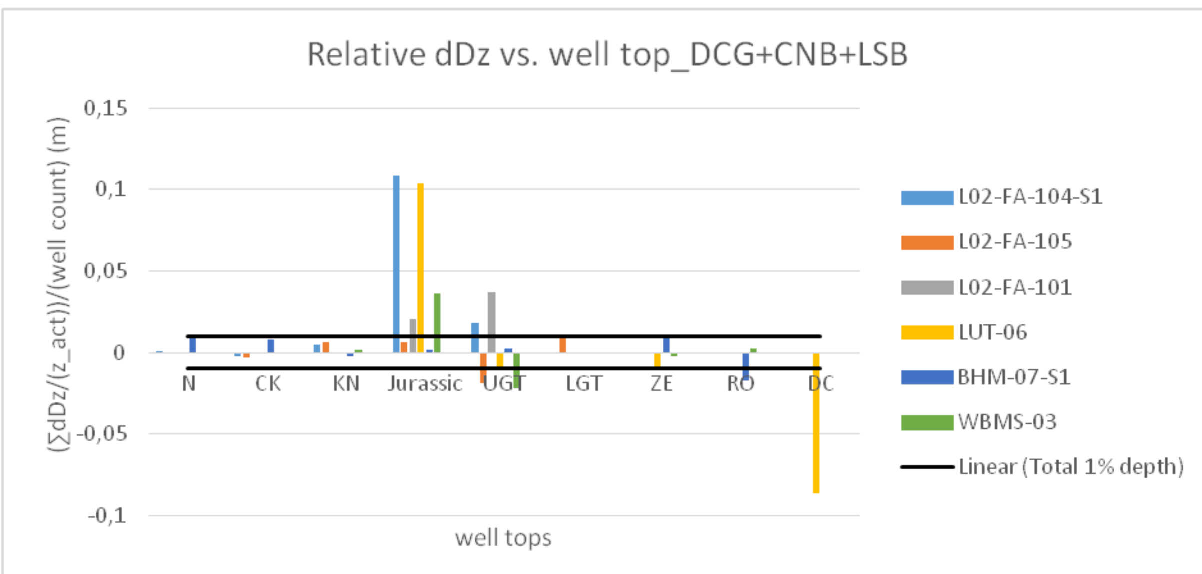


Figure 75 - Average, relative dDz vs. well top for individual wells in the structural element DCG+CNB+LSB. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 39-40) for a discussion of the diagram.

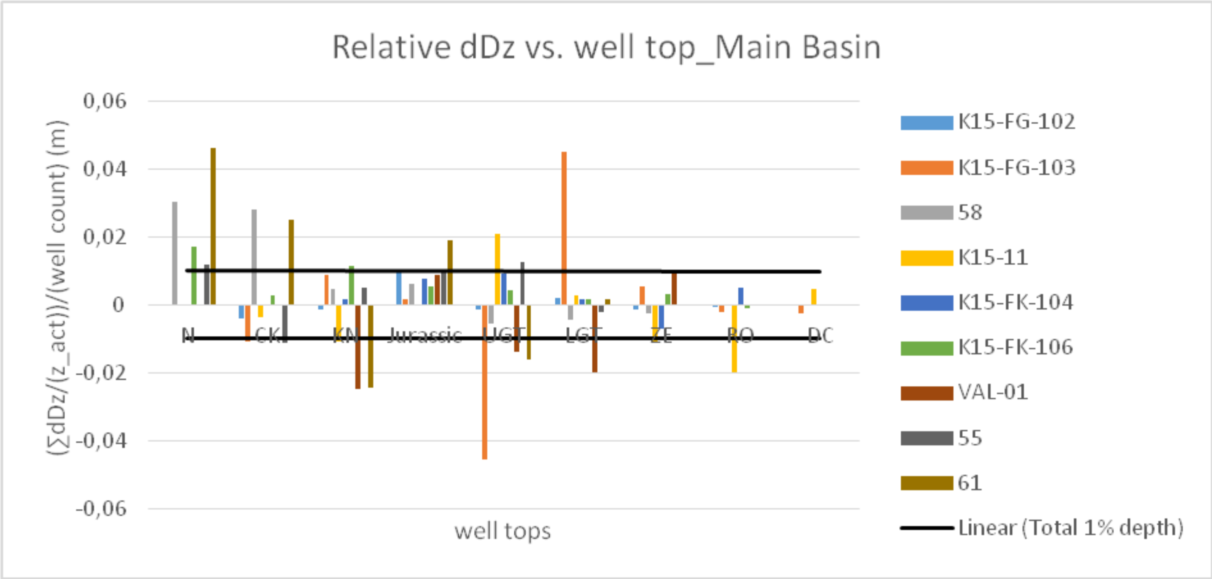


Figure 76 - Average, relative dDz vs. well top for individual wells in the structural element Main Basin. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 39-40) for a discussion of the diagram.

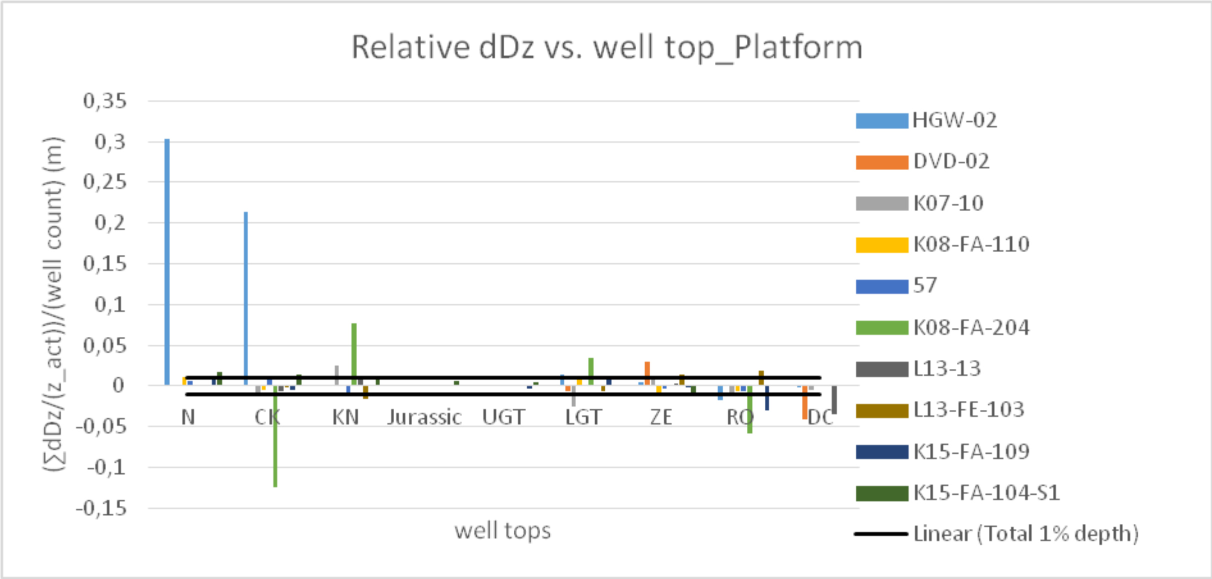


Figure 77 - Average, relative dDz vs. well top for individual wells in the structural element Platform. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 39-40) for a discussion of the diagram.

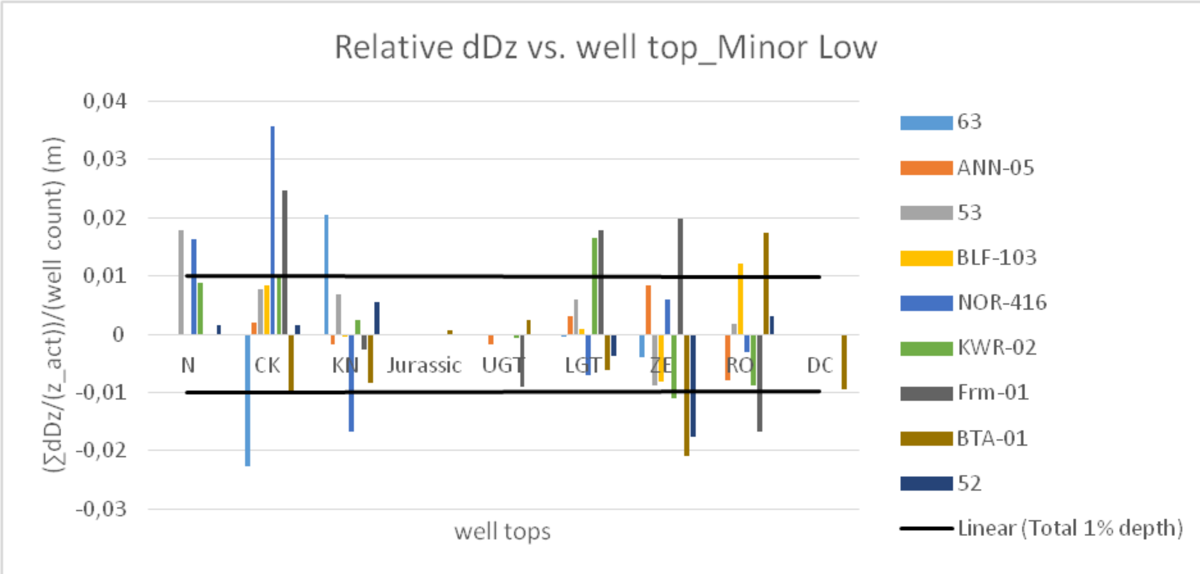


Figure 78 - Average, relative dDz vs. well top for individual wells in the structural element Minor Low. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 39-40) for a discussion of the diagram.

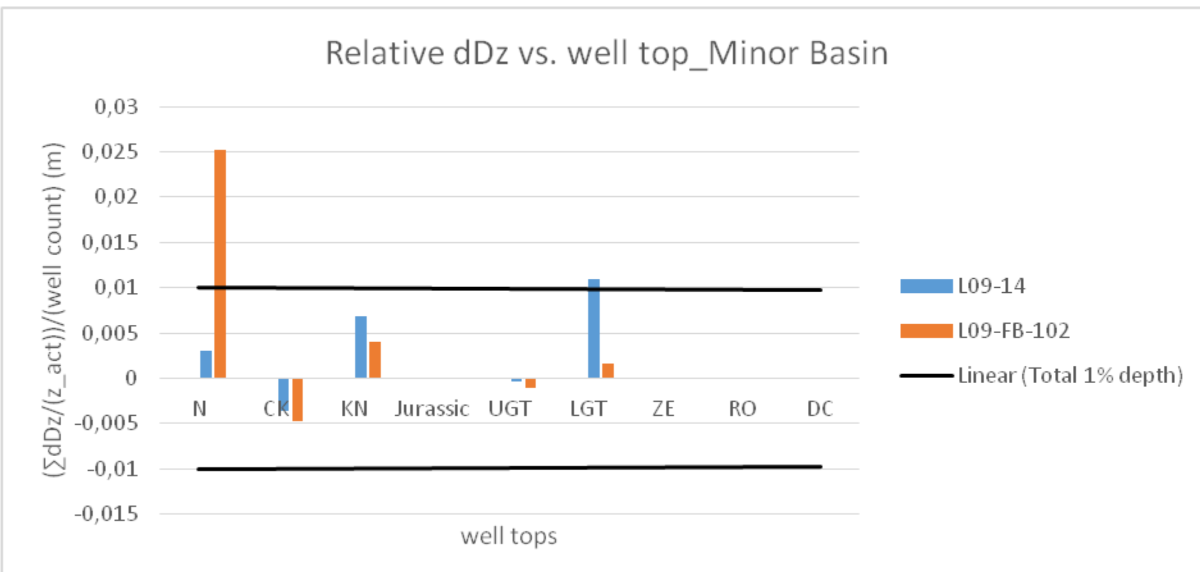


Figure 79 - Average, relative dDz vs. well top for individual wells in the structural element Minor Basin. For the top North Sea Group and top Jurassic, T2Dcon errors of the individual wells are absolute average values. See appendix 4 for a list of abbreviations of the stratigraphic units. See the report text (pp. 39-40) for a discussion of the diagram.

3. List of abbreviations of stratigraphic units

Period	Supergroup	Group	Subgroup	Formation	Member		Official name Nomenclature	strat_order
Tertiary and Quaternary	N					N	North Sea Supergroup	1
		NU				NU	Upper North Sea Group	2
				NUMS		NUMS	Maassluis Formation	3
				NUOT		NUOT	Oosterhout Formation	4
				NUSA		NUSA	Scheemda Formation	5
				NUKO		NUKO	Kieseloolite Formation	6
					NUKOR	NUKOR	Reuver Clay Member	7
					NUKOS	NUKOS	Schinveld Sand Member	8
					NUKOB	NUKOB	Brunssum Clay Member	9
					NUKOV	NUKOV	Venlo Clay Member	10
					NUKOW	NUKOW	Waubach Sand and Gravel Member	11
				NUBA		NUBA	Breda Formation	12
					NUBAU	NUBAU	upper Breda member	13
					NUBAL	NUBAL	lower Breda member	14
					NUBAK	NUBAK	Kakert Member	15
				NUIN		NUIN	Inden Formation	16
				NUVI		NUVI	Ville Formation	17
					NUVIH	NUVIH	Heksenberg Member	18
		NM				NM	Middle North Sea Group	19
				NMVF		NMVF	Veldhoven Formation	20
					NMVFS	NMVFS	Someren Member	21
					NMVFO	NMVFO	Veldhoven Clay Member	22
					NMVFV	NMVFV	Voort Member	23
				NMRF		NMRF	Rupel Formation	24
					NMRFT	NMRFT	Steensel Member	25
					NMRFC	NMRFC	Rupel Clay Member	26
					NMRFV	NMRFV	Vessem Member	27
					NMRFW	NMRFW	Winterswijk Member	28
					NMRFH	NMRFH	Brinkheurne Member	29
					NMRFR	NMRFR	Ratum Member	30
				NMTF		NMTF	Tongeren Formation	31
					NMTFG	NMTFG	Goudsberg Member	32
					NMTFK	NMTFK	Klimmen Member	33
		NL				NL	Lower North Sea Group	34
				NLFF		NLFF	Dongen Formation	35
					NLFFB	NLFFB	Asse Member	36
					NLFFS	NLFFS	Brussels Sand Member	37
					NLFFM	NLFFM	Brussels Marl Member	38
					NLFFY	NLFFY	Ieper Member	39
					NLFFC	NLFFC	Dongen Clay Member	40
					NLFFD	NLFFD	Basal Dongen Sand Member	41
					NLFFT	NLFFT	Basal Dongen Tuffite Member	42
				NLLF		NLLF	Landen Formation	43
					NLLFR	NLLFR	Reusel Member	44
					NLLFC	NLLFC	Landen Clay Member	45
					NLLFG	NLLFG	Gelinden Member	46
					NLLFS	NLLFS	Heers Member	47
					NLLFL	NLLFL	Swalmen Member	48
Upper Cretaceous		CK				CK	Chalk Group	49
				CKEK		CKEK	Ekofisk Formation	50
				CKGR		CKGR	Ommelanden Formation	51
				CKHM		CKHM	Houthem Formation	52
				CKMA		CKMA	Maastricht Formation	53
				CKGP		CKGP	Gulpen Formation	54
				CKVA		CKVA	Vaals Formation	55
				CKAK		CKAK	Aken Formation	56
				CKTX		CKTX	Texel Formation	57
					CKTXM	CKTXM	Texel Marlstone Member	58
					CKTXG	CKTXG	Texel Greensand Member	59
					CKTXP	CKTXP	Plenus Marl Member	60
		KN				KN	Rijnland Group	61
				KNGL		KNGL	Holland Formation	62
					KNGLU	KNGLU	Upper Holland Marl Member	63
					KNGLM	KNGLM	Middle Holland Claystone Member	64
					KNGLG	KNGLG	Holland Greensand Member	65
					KNGLS	KNGLS	Spijkenisse Greensand Member	66

Overlap Shallow Subsurface

Period	Supergroup	Group	Subgroup	Formation	Member		Official name Nomenclature	strat_order
Lower Cretaceous					KNGLL	KNGLL	Lower Holland Marl Member	67
			KNN			KNN	Vlieland subgroup	68
				KNNC		KNNC	Vlieland Claystone Formation	69
					KNNCK	KNNCK	Vlieland Marl Member	70
					KNNCM	KNNCM	Vlieland Claystone member	71
					KNNCW	KNNCW	Westerbork Member	72
					KNNCE	KNNCE	Ruinen Member	73
					KNNCS	KNNCS	Schoonebeek Member	74
					KNNCV	KNNCV	Bentheim Claystone Member	75
					KNNCU	KNNCU	Eemhaven Member	76
					KNNCA	KNNCA	IJsselmonde Claystone Member	77
				KNNS		KNNS	Vlieland Sandstone Formation	78
					KNNSF	KNNSF	Friesland Member	79
					KNNSK	KNNSK	Kotter Member	80
					KNNSH	KNNSH	Helder Member	81
					KNNSO	KNNSO	Logger Sandstone member	82
					KNNSG	KNNSG	Gildehaus Sandstone Member	83
					KNNSP	KNNSP	Bentheim Sandstone Member	84
					KNNSL	KNNSL	De Lier Member	85
					KNNSY	KNNSY	IJsselmonde Sandstone Member	86
					KNNSD	KNNSD	Berkel Clastics member	87
					KNNSB	KNNSB	Berkel Sandstone Member	88
					KNNSC	KNNSC	Berkel Sand-Claystone Member	89
					KNNSR	KNNSR	Rijswijk Member	90
					KNNSI	KNNSI	Rijn Member	91
				XXZV		XXZV	Zuidwal Volcanic Formation	92
Upper Jurassic		SK				SK	Niedersaksen Group	93
				SKCF		SKCF	Coevorden Formation	94
					SKCFU	SKCFU	Upper Coevorden Member	95
					SKCFM	SKCFM	Middle Coevorden Member	96
					SKCFL	SKCFL	Lower Coevorden Member	97
				SKWF		SKWF	Weiteveen Formation	98
					SKWFF	SKWFF	Serpulite Member	99
					SKWFE	SKWFE	Weiteveen Upper Marl Member	100
					SKWFD	SKWFD	Weiteveen Upper Evaporite Member	101
					SKWFC	SKWFC	Weiteveen Lower Marl Member	102
					SKWFB	SKWFB	Weiteveen Lower Evaporite Member	103
					SKWFA	SKWFA	Weiteveen Basal Clastic Member	104
		SG				SG	Scruff Group	105
				SGGS		SGGS	Scruff Greensand Formation	106
					SGGSS	SGGSS	Stortemelk Member	107
					SGGSP	SGGSP	Scruff Spiculite Member	108
					SGGSA	SGGSA	Scruff Argillaceous Member	109
					SGGSB	SGGSB	Scruff Basal Sandstone Member	110
				SGKI		SGKI	Kimmeridge Clay Formation	111
					SGKIS	SGKIS	Schill Grund Member	112
					SGKIC	SGKIC	Clay Deep Member	113
					SGKIM	SGKIM	main Kimmeridge Clay member	114
		SL				SL	Schieland Group	115
			SLD			SLD	Delfland Subgroup	116
				SLDZ		SLDZ	Zurich Formation	117
					SLDZU	SLDZU	upper Zurich member	118
					SLDZV	SLDZV	Wadden Volcaniclastic Member	119
					SLDZL	SLDZL	lower Zurich member	120
				SLDB		SLDB	Breeveertien Formation	121
					SLDBH	SLDBH	Helm Member	122
					SLDBN	SLDBN	Neomiodon Claystone Member	123
					SLDBB	SLDBB	Bloemendaal Member	124
					SLDBD	SLDBD	Driehuis Mottled Claystone Member	125
					SLDBS	SLDBS	Santpoort Member	126
					SLDBC	SLDBC	Fourteens Claystone Member	127
					SLDBA	SLDBA	Aerdenhout Member	128
				SLDN		SLDN	Nieuwerkerk Formation	129
					SLDNR	SLDNR	Rodenrijs Claystone Member	130
					SLDND	SLDND	Delft Sandstone Member	131
					SLDNA	SLDNA	Alblasserdam Member	132

Period	Supergroup	Group	Subgroup	Formation	Member		Official name Nomenclature	strat_order
			SLC			SLC	Central Graben Subgroup	133
				SLCU		SLCU	Upper Graben Formation	134
				SLCM		SLCM	Middle Graben Formation	135
					SLCMU	SLCMU	upper claystone member	136
					SLCMS	SLCMS	Middle Graben Sandstone Member	137
					SLCML	SLCML	lower claystone member	138
				SLCL		SLCL	Lower Graben Formation	139
				SLCP		SLCP	Puzzle Hole Formation	140
				SLCF		SLCF	Friese Front Formation	141
					SLCFT	SLCFT	Terschelling Sandstone Member	142
					SLCFO	SLCFO	Oyster Ground Claystone Member	143
					SLCFM	SLCFM	main Friese Front member	144
					SLCFR	SLCFR	Rifgronden Member	145
Middle and Lower Jurassic		AT				AT	Altena Group	146
				ATBR		ATBR	Brabant Formation	147
					ATBRO	ATBRO	Oisterwijk Limestone Member	148
					ATBRU	ATBRU	Upper Brabant Marl Member	149
					ATBR3	ATBR3	Upper Brabant Limestone Member	150
					ATBRM	ATBRM	Middle Brabant Marl Member	151
					ATBR2	ATBR2	Middle Brabant Limestone Member	152
					ATBRL	ATBRL	Lower Brabant Marl Member	153
					ATBR1	ATBR1	Lower Brabant Limestone Member	154
					ATBRK	ATBRK	Klomps member	155
				ATWD		ATWD	Werkendam Formation	156
					ATWDU	ATWDU	Upper Werkendam Member	157
					ATWDM	ATWDM	Middle Werkendam Member	158
					ATWDL	ATWDL	Lower Werkendam Member	159
				ATPO		ATPO	Posidonia Shale Formation	160
				ATAL		ATAL	Aalburg Formation	161
				ATRT		ATRT	Sleen Formation	162
Triassic		RN				RN	Upper Germanic Trias Group	163
				RNKP		RNKP	Keuper Formation	164
					RNKPC	RNKPC	Argillaceous Keuper member	165
					RNKPU	RNKPU	Upper Keuper Claystone Member	166
					RNKPD	RNKPD	Dolomitic Keuper Member	167
					RNKPR	RNKPR	Red Keuper Claystone Member	168
					RNKPE	RNKPE	Red Keuper Evaporite Member	169
					RNKPM	RNKPM	Middle Keuper Claystone Member	170
					RNKPS	RNKPS	Main Keuper Evaporite Member	171
					RNKPL	RNKPL	Lower Keuper Claystone Member	172
				RNMU		RNMU	Muschelkalk Formation	173
					RNMUU	RNMUU	Upper Muschelkalk Member	174
					RNMUA	RNMUA	Middle Muschelkalk Marl Member	175
					RNMUE	RNMUE	Muschelkalk Evaporite Member	176
					RNMUL	RNMUL	Lower Muschelkalk Member	177
					RNMUM	RNMUM	Middle Muschelkalk member	178
					RNMUC	RNMUC	Muschelkalk Claystone member	179
				RNRO		RNRO	Röt Formation	180
					RNROU	RNROU	Upper Röt Claystone Member	181
					RNRO2	RNRO2	Upper Röt Evaporite Member	182
					RNROM	RNROM	Intermediate Röt Claystone Member	183
					RNRO1	RNRO1	Main Röt Evaporite Member	184
					RNROY	RNROY	Upper Röt Fringe Claystone Member	185
					RNROF	RNROF	Röt Fringe Sandstone Member	186
					RNROL	RNROL	Lower Röt Fringe Claystone Member	187
					RNROC	RNROC	Röt Claystone Member	188
				RNSO		RNSO	Solling Formation	189
					RNSOC	RNSOC	Solling Claystone Member	190
					RNSOB	RNSOB	Basal Solling Sandstone Member	191
					RNSOU	RNSOU	upper Solling Claystone member	192
					RNSOF	RNSOF	Solling fat sandstone member	193
					RNSOL	RNSOL	lower Solling Claystone member	194
		RB				RB	Lower Germanic Trias Group	195
			RBM			RBM	Main Buntsandstein Subgroup	196
				RBMH		RBMH	Hardegsen Formation	197
				RBMD		RBMD	Detfurth Formation	198

Period	Supergroup	Group	Subgroup	Formation	Member		Official name Nomenclature	strat_order
					RBMDU	RBMDU	Upper Detfurth Sandstone Member	199
					RBMDC	RBMDC	Detfurth Claystone Member	200
					RBMDL	RBMDL	Lower Detfurth Sandstone Member	201
				RBMV		RBMV	Volpriehausen Formation	202
					RBMVA	RBMVA	Volpriehausen Avicula Member	203
					RBMVU	RBMVU	Upper Volpriehausen Sandstone Member	204
					RBMVC	RBMVC	Volpriehausen Clay-Siltstone Member	205
					RBMVL	RBMVL	Lower Volpriehausen Sandstone Member	206
				RBSH		RBSH	Lower Buntsandstein Formation	207
					RBSHR	RBSHR	Rogenstein Member	208
					RBSHM	RBSHM	Main Claystone Member	209
					RBSHN	RBSHN	Nederweert Sandstone Member	210
Permian		ZE				ZE	Zechstein Group	211
				ZEUC		ZEUC	Zechstein Upper Claystone Formation	212
				ZEZ5		ZEZ5	Z5 (Ohre) Formation	213
					ZEZ5H	ZEZ5H	Z5 Salt Member	214
					ZEZ5R	ZEZ5R	Z5 Salt Clay Member	215
					ZEZ4T	ZEZ4T	Z4 Upper Anhydrite. Member	216
				ZEZ4		ZEZ4	Z4 (Aller) Formation	217
					ZEZ4S	ZEZ4S	Z4 Fringe Sandstone Member	218
					ZEZ4H	ZEZ4H	Z4 Salt Member	219
					ZEZ4A	ZEZ4A	Z4 Pegmatite Anhydrite Member	220
					ZEZ4R	ZEZ4R	Red Salt Clay Member	221
				ZEZ3		ZEZ3	Z3 (Leine) Formation	222
					ZEZ3U	ZEZ3U	Z3 Fringe Claystone Member	223
					ZEZ3H	ZEZ3H	Z3 Salt Member	224
					ZEZ3A	ZEZ3A	Z3 Main Anhydrite Member	225
					ZEZ3C	ZEZ3C	Z3 Carbonate Member	226
					ZEZ3B	ZEZ3B	Z3 Anhydrite/Carbonate Member	227
					ZEZ3S	ZEZ3S	Z3 Fringe Sandstone Member	228
					ZEZ3G	ZEZ3G	Grey Salt Clay Member	229
				ZEZ2		ZEZ2	Z2 (Stassfurt) Formation	230
					ZEZ2S	ZEZ2S	Z2 Fringe Sandstone Member	231
					ZEZ2T	ZEZ2T	Z2 Roof Anhydrite Member	232
					ZEZ2H	ZEZ2H	Z2 Salt Member	233
					ZEZ2A	ZEZ2A	Z2 Basal Anhydrite Member	234
					ZEZ2M	ZEZ2M	Z2 Middle Claystone Member	235
					ZEZ2F	ZEZ2F	Z2 Fringe Anhydrite Member	236
					ZEZ2C	ZEZ2C	Z2 Carbonate Member	237
					ZEZ2R	ZEZ2R	Red-brown Salt Clay Member	238
				ZEZ1		ZEZ1	Z1 (Werra) Formation	239
					ZEZ1S	ZEZ1S	Z1 Fringe Sandstone Member	240
					ZEZ1W	ZEZ1W	Z1 Anhydrite Member	241
					ZEZ1C	ZEZ1C	Z1 Carbonate Member	242
					ZEZ1K	ZEZ1K	Coppershale Member	243
					ZEZ1T	ZEZ1T	Z1 Upper Anhydrite Member	244
					ZEZ1H	ZEZ1H	Z1 Salt Member	245
					ZEZ1A	ZEZ1A	Z1 Lower Anhydrite Member	246
					ZEZ1B	ZEZ1B	Z1 Anhydriet/Carbonate Member	247
					ZEZ1M	ZEZ1M	Z1 Middle Claystone Member	248
					ZEZ1F	ZEZ1F	Z1 Fringe Carbonate Member	249
					ZEZ1G	ZEZ1G	Z1 Lower Claystone Member	250
					ZEZ1E	ZEZ1E	Fringe Coppershale Member	251
					ZEUN	ZEUN	Zechstein undifferentiated	252
					ZESAU	ZESAU	Upper Zechstein salt	253
					ZESAL	ZESAL	Lower Zechstein salt	254
					ZECP	ZECP	Zechstein caprock	255
					ZESA	ZESA	Zechstein salt	256
					ZEFC	ZEFC	Zechstein Fringe clastics	257
					ZEFRM	ZEFRM	Zechstein Middle claystone	258
					ZEFRS	ZEFRS	Zechstein Fringe sandstone	259
		RO				RO	Upper Rotliegend Group	260
				ROCL		ROCL	Silverpit Formation	261
					ROCLT	ROCLT	Ten Boer Member	262
					ROCLA	ROCLA	Ameland Member	263
					ROCLH	ROCLH	Hollum Member	264

Period	Supergroup	Group	Subgroup	Formation	Member		Official name Nomenclature	strat_order
					ROCLB	ROCLB	Buren Member	265
					ROCLU	ROCLU	Upper Silverpit Claystone Member	266
					ROCLE	ROCLE	Silverpit Evaporite Member	267
					ROCLL	ROCLL	Lower Silverpit Claystone Member	268
				ROSL		ROSL	Slochteren Formation	269
					ROSLA	ROSLA	Akkrum Sandstone Member	270
					ROSLU	ROSLU	Upper Slochteren Member	271
					ROSLL	ROSLL	Lower Slochteren Member	272
		RV				RV	Lower Rotliegend Group	273
				RVVE		RVVE	Emmen Volcanic Formation	274
				RVBA		RVBA	Basal Rotliegend clastics	275
Carboniferous		DC				DC	Limburg Groep	276
			DCH			DCH	Hunze Subgroup	277
				DCHP		DCHP	Step Graben Formation	278
				DCHS		DCHS	Strijen Formation	279
				DCHL		DCHL	De Lutte Formation	280
			DCD			DCD	Dinkel Subgroup	281
				DCDG		DCDG	Hospital Ground Formation	282
				DCDN		DCDN	Neeroeteren Formation	283
				DCDH		DCDH	Hellevoetsluis Formation	284
				DCDT		DCDT	Tubbergen Formation	285
			DCC			DCC	Caumer Subgroup	286
				DCCU		DCCU	Maurits Formation	287
				DCCR		DCCR	Ruurlo Formation	288
				DCCB		DCCB	Baarlo Formation	289
				DCCK		DCCK	Klaverbank Formation	290
					DCCKB	DCCKB	Botney Member	291
					DCCKM	DCCKM	Main Klaverbank Member	292
					DCCUK	DCCUK	Kemperkoul Member	293
			DCG			DCG	Geul Subgroep	294
				DCGM		DCGM	Millstone Grit Formation	295
				DCGE		DCGE	Epen Formation	296
					DCGET	DCGET	upper Epen member	297
					DCGEM	DCGEM	main Epen member	298
					DCGEU	DCGEU	Ubachsberg Member	299
					DCGEG	DCGEG	Geverik Member	300
		CL				CL	Carboniferous Limestone Group	301
				CLZL		CLZL	Zeeland Formation	302
					CLZLG	CLZLG	Goeree Member	303
					CLZLS	CLZLS	Schouwen Member	304
					CLZLB	CLZLB	Beveland Member	305
		CF				CF	Fame Group	306
				CFYD		CFYD	Yoredale Formation	307
				CFEB		CFEB	Elleboog Formation	308
				CFCS		CFCS	Cementstone Formation	309
Devonian		OB				OB	Banjaard group	310
				OBBS		OBBS	Bosscheveld formation	311
				OBGC		OBGC	Bollen claystone formation	312
				OBWS		OBWS	Winterswijk formation	313
		OR				OR	Old Red Group	314
				ORTP		ORTP	Tayport Formation	315
				ORBU		ORBU	Buchan Formation	316
				ORPA		ORPA	Patch Formation	317
Silurian		SI				SI	Silurian	318
Ordovician		OV				OV	Ordovician	319
Cambriium		CA				CA	Cambrian	320

Table 13 – List of abbreviations from the North Sea area stratigraphic nomenclature from TNO.