DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2012/64

Interpretation of analytical results from the Terne-1 and Slagelse-1 wells

TOC, XRD, trace elements and carbon isotope analysis

Niels H. Schovsbo

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1. Introduction

This report is prepared for TOTAL E&P Denmark B.V. and presents the interpretation of analytical results from the Lower Palaeozoic interval in the Terne-1 and Slagelse-1 wells. The results are presented in the GEUS Report 2012/28 (Schovsbo 2012).

This report comprises of four parts:

Part 1: Interpretation of additional TOC and XRD analyses from the Slagelse-1 well.

Part 2: Interpretation of additional TOC and XRD analyses from the Terne-1 well.

Part 3: Chemostratigraphical analysis of the Terne-1 well based on trace elements and stable isotope data.

Part 4: Comparison of XRD measurements. Analytical results from: 1) GEUS clay laboratory, 2) the XRD laboratory at the Geological Museum, University of Copenhagen and 3) data provided by TOTAL E&P.

2. Part 1 TOC and XRD analysis from the Slagelse-1 well

A total of 45 samples from the Slagelse-1 well have been measured for TOC content and mineralogical composition (Schovsbo 2012). Of these samples 25 were not included in the review of the Slagelse-1 well (Schovsbo 2011a) and below are updated tables and figures for the well including the additional samples.

As part of a re-assessment of the XRD analyses performed by GEUS 13 samples were re-analysed by the XRD laboratory at the Geological Museum in November 2012. The evaluation of the XRD in the Slagelse-1 well is treated in section 5 of this report and revised mineralogical compositions is presented in Appendix B. The data in Appendix B replaces the analysis presented in Schovsbo (2011a, 2012).

Sampling procedure

The samples were picked form cores and cuttings in the well. Cavings of red sandstone (Triassic or Lower Permian) were present in most cutting samples and were removed prior to analysis. In the Alum Shale interval the cuttings showed a mix between dark and green lithologies attributed to caving of material from the Ordovician/Silurian sequence. Only the darkest cuttings were selected for analysis in order to provide an estimate of the TOC content of this rock type.

Prior to analysis the cutting samples were washed with water to remove drill-mud. After drying approximately 2 g of material was picked from the 1-4 mm fraction. Magnetic material was removed and the samples were crushed to a grain size below 250 my. No chemical or physical pre-treatment of the core samples were made.

2.1. TOC content

In the Alum Shale the TOC content measured on core samples ranges from 7.2-8.6% whereas the cutting samples contain 0.2-3% TOC. The cutting samples are thus interpreted to include caved Ordovician and Silurian cuttings despite the fact that only the darkest lithologies were analysed.

A relationship between TOC content and GR log response in the Slagelse-1 well has been established based on the TOC content measured on the core samples (Figure 1).

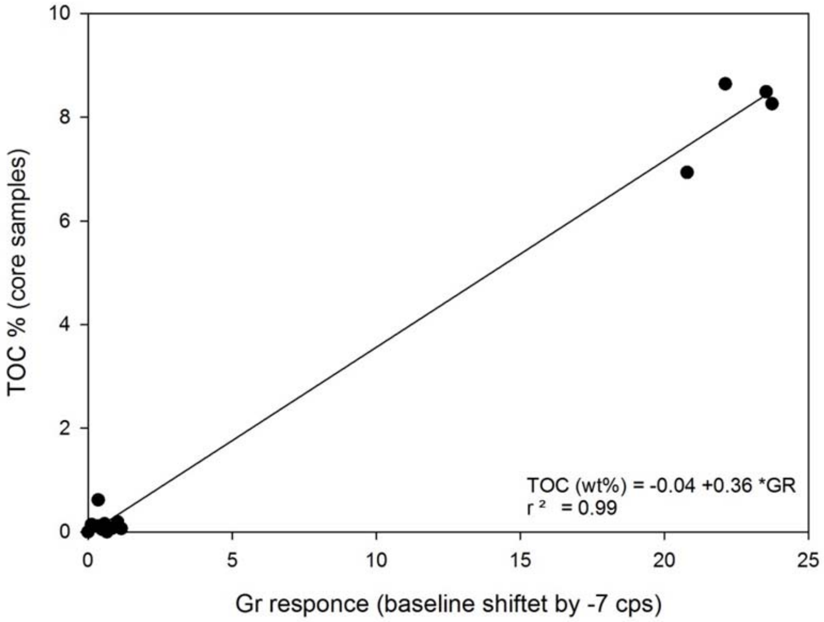

Figure 1. Relationship between TOC measured on core samples and the GR response in the Slagelse-1 well. The relationship between TOC and GR response has been described by a linear relationship since the few data points do not allow more sophisticated relationships to be tested. The calculated TOC concentrations from the GR log are presented in Figure 2.

The calculated TOC content varies between 6-10% in the Furongian and between 0-4% in the Middle Cambrian (Figure 2). The cuttings from the Furongian interval have TOC contents similar to the Ordovician and Silurian shales (i.e. <0.2%) and are almost certainly contaminated by these lithologies. The cuttings picked from the Middle Cambrian have TOC content that are only about 25-50% lower compared to the calculated TOC content (Figure 2) and thus probably contain much less caved TOC lean material.

In the Ordovician and Silurian interval the highest TOC content measured is 0.6% (at 2770.8 m). In all other samples the TOC concentrations are below 0.5%. This indicates that no other Palaeozoic TOC rich units beside the Alum Shale were drilled in the Slagelse-1 well.

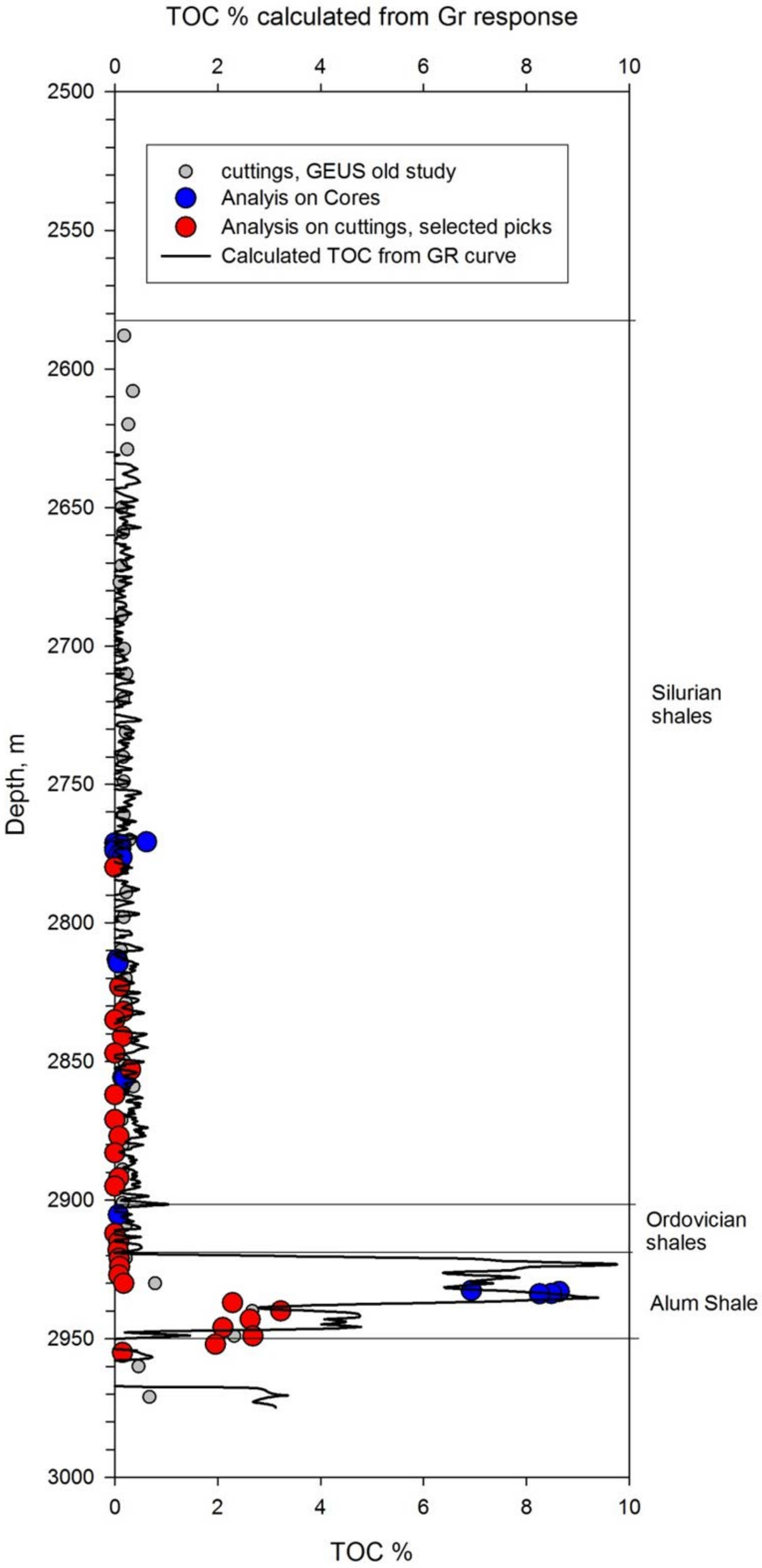

Figure 2. TOC distribution in the Slagelse-1 well (update of Figure 11 in Schovsbo 2011a). The TOC content has been calculated from the GR curve based on the relationship presented in Figure 1.

Table 1. Stratigraphical picks and range of TOC content in the units. The table is an update of Table 2 presented in Schovsbo (2011a).

Depth, m MD	Pick name	Unit/interval	Thickness	Main Lithology	Range in TOC %
2625.0	Top Pre-Zechstein				
2903.0	Base Silurian	Silurian	278.0	Grey green silty mudstone	0.1-0.6 (core)
2919.6	Base Lindegård Fm?	Lindegård Fm?	16.6	Grey green mudstone	0.1-0.2 (cuttings)
2919.6	Base Upper Ordovician	Upper Ordovician	16.6		0.1-0.2 (cuttings)
2919.6	Top Alum Shale				
2925.6	Base *Peltura* Zone	*Peltura* Zones	6.0	Dark mudstone	
2932.0	Base *Parabolina* Zone	*Parabolina* + *Leptoplastus* zones	6.3	Dark mudstone	
2939.2	Base *Olenus* Zone	*Olenus* Zone	7.3	Dark mudstone	7.2-8.6 (core)
2939.2	Base Furongian / Top Middle Cambrian	Furongian Alum Shale	19.6	Dark mudstone	2.1-3.2 (cuttings)
		Middle Cambrian Alum Shale	10.2	Dark mudstone	
2949.4	Base Alum Shale / Top Gislöv Fm	Alum Shale Fm	29.8	Dark mudstone	0.1-2.7 (cuttings)
2957.7	Base Gislöv Fm / Top Læså Fm	Gislöv Fm	8.3	Siltstone-sandstone	0.5 (cuttings)
2969.8	Top Hardeberga	Læså Fm	12.1	Sandstone	0.7 (cuttings)

2.2. Mineralogical analysis

In the Alum Shale the quartz content measured on core sample ranges between 22-29% (Figure 3). The cuttings measured in the formation range between 25-29%. The cutting samples from eth Alum Shale are interpreted to contain a high proportion of caving and the mineralogy measured on the cutting fraction may not represent the properties of the sample level.

The quartz to total clay ratio in the Alum Shale range between 0.4-0.6 (Figure 3).

Within the Ordovician and Silurian interval the variability in the quartz content is rather large and ranges between 19-59%. Highest concentrations are measured in silty beds, which occur intercalated with mudstone in the Silurian section (Figure 3).

The quartz to total clay ratio in the Ordovician-Silurian interval range between 0.3-1.7 (Figure 3).

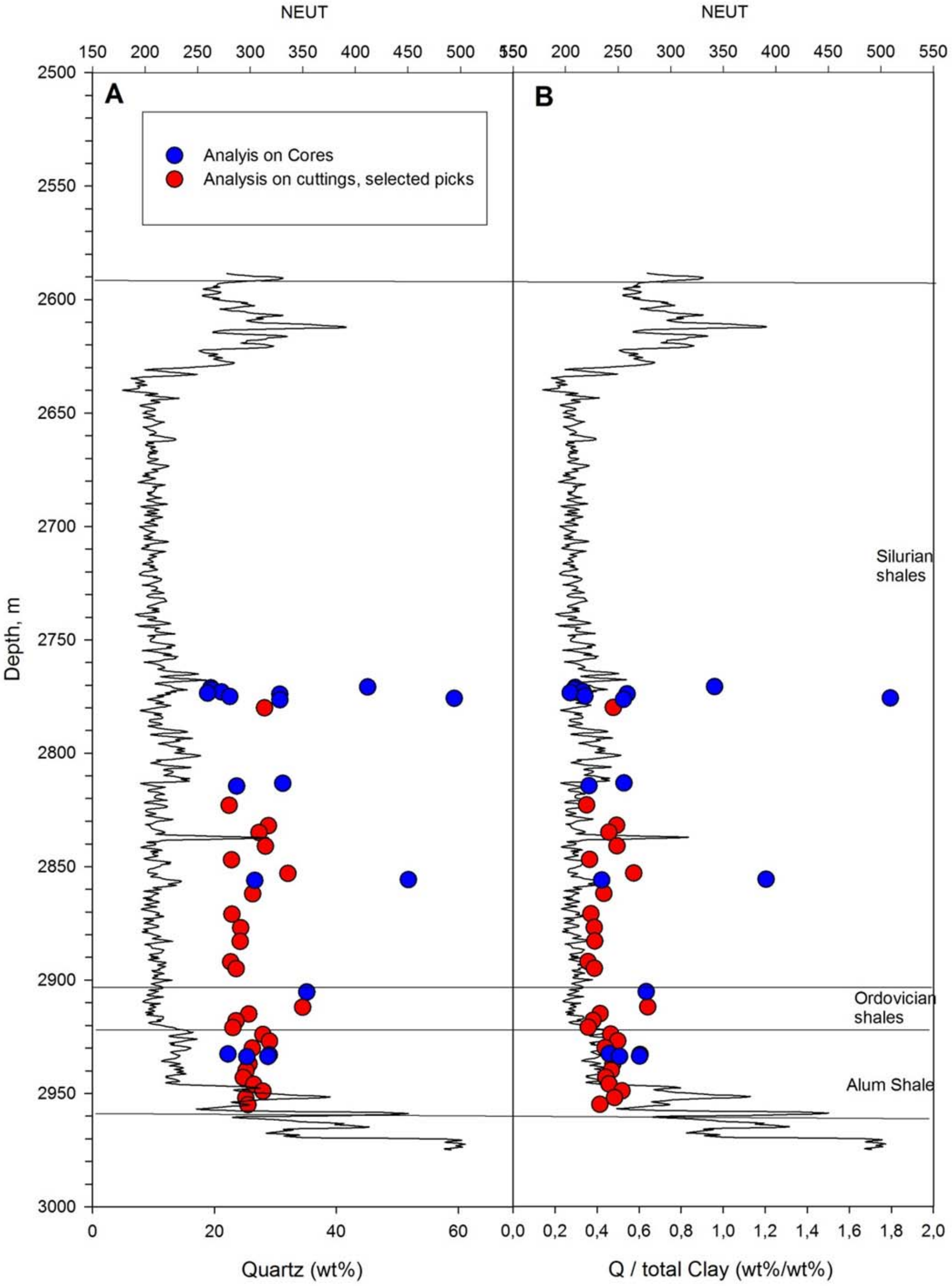

Figure 3. Stratigraphical variation of A) the quartz content and B) the quartz / total clay ratio. The total neutron log (NEUT) curve measured in the bore hole is shown for reference. The figure is an update of Figure 13 in Schovsbo (2011a). Data is presented in Appendix B.

3. Part 2 TOC and XRD analyses from the Terne-1 well

TOC and carbonate content in 88 samples have been measured in the Terne-1 well (Schovsbo 2012). In the review of the Terne-1 well (Schovsbo 2011b) the analytical results for 20 of these samples were presented. Below are updated tables, diagrams and interpretation presented in Schovsbo (2011b) including the additional analytical results.

A re-assessment of the XRD analyses made by GEUS is presented in Part 4 of this report (chapter 5) and an update of the XRD results for the well are presented in Appendix A. The XRD data presented here replaces the XRD data presented in Schovsbo (2011b) and in Schovsbo (2012).

About the samples
All samples are cuttings since no core was obtained in the shale section. The cuttings do not show a mix of different lithologies. In the Alum Shale interval the cuttings showed consistent dark shale lithology with occasional white carbonate grains. No selective picking of the cuttings were made from the samples; only magnetic material was removed from the samples. Prior to analysis the samples were washed with water. After drying approximately 2 g of material was picked from the 1-4 mm fraction and crushed to a grain size below 250 my.

Table 2. Pick depth table for the Terne-1 well (from Schovsbo 2011b, Schovsbo & Nielsen 2012). The pick depth are modified for the top M. Cambrian and top *Lejopyge* as compared to the pick depths presented in Schovsbo & Nielsen (2012).

Pick name	**TERNE-1**
T_Prezechstein	2312.7
Top_rastrites	2755.7
F5_base	2812.6
F4_base	2857.6
F3_base	2938.0
F2_base	2958.2
Base_Silurian	2977.4
F1_base	2981.9
E3_base	2991.8
E2_base	3000.7
E1_base	3024.3
U_Ordovician	3088.1
top_komstad	3122.0
top_toeyen	3122.0
top_bjoerkaasholmen	3173.2
top_alum	3173.5
top_D2	3186.6
top_D1	3203.2
top_furongian	3207.6
top_scarabaeoides	3220.2
top_minor	3234.8
top_protopeltura	3240.2
top_leptoplastus	3244.6
top_parabolina	3246.7
top_olenus	3256.8
top_m_cambrian	3272.1
top_lejopyge	3277.7
top_andrarum	3294.8
base_Andrarum	3300.5
top_B2	3320.4
top_exsulans	3327.5
base_Exsulans	3334.1
base_forsamolla	3341.8
top_gislov	3351.7
top_laesaa	3351.8
top_Hardeberga	3351.8

3.1. TOC content

The TOC content is shown in Figures 4 to 6 and a stratigraphical breakdown of the variation is presented in Table 3.

TOC in the Alum Shale

The TOC content ranges between 2.6-13.7% with average values of 6.4% for the formation (Table 3). There is a clear relationship between stratigraphical level and TOC content. Intermediate TOC values are measured in the Middle Cambrian (5.2%), highest values are measured in the Furongian part (9.0%) and lowest TOC values are measured in the Tremadocian part of the formation (4.1%).

The average TOC content within the Middle Cambrian and the Furongian are similar to what has been measured in Scania (i.e. compare with the Albjära-1 core in Table 3). In the Albjära-1 the Furongian part of the formation contains on average 10.1% TOC and the Middle Cambrian on average 5.3% TOC (Table 3). In the Tremadocian part of the formation, however, lower TOC values has been measured in the Terne-1 well (average 4.1%) as compared to those measured in Albjära core (average 6.2% TOC).

TOC in the Ordovician interval overlying the Alum Shale

The Tøyen and Almelund shales have on average 1.3% and 1.1% TOC, respectively, in the Terne-1 well (Table 3). Compared to Scania the TOC level in the Almelund shale is about the same whereas slightly higher levels are measured in the Tøyen Shale as compared to Scania (e.g. compare to Schovsbo 2003).

The average TOC content in the Dicellograptus Shale is 1.1% in the Terne-1 well and the highest TOC value measured in the topmost part of the unit is 1.5% (Figure 17). Based on the TOC measurements from this unit on Bornholm it was expected that the Fjäcka level in the topmost part of the Dicellograptus Shale should contain up to 4% TOC (Schovsbo 2011b). This might suggest that the most organic rich part of the Dicellograptus shale is not present in the Terne-1 well.

TOC in the Silurian interval

TOC rich intervals occur in the F1, F2 and F4 units (Table 3). The F4 unit is the most enriched and has on average 1.6% TOC and the F1 unit has on average 1.1% TOC. The TOC enrichment is in agreement with the log response that indicates the presence of organic rick mudstone (Figure 6).

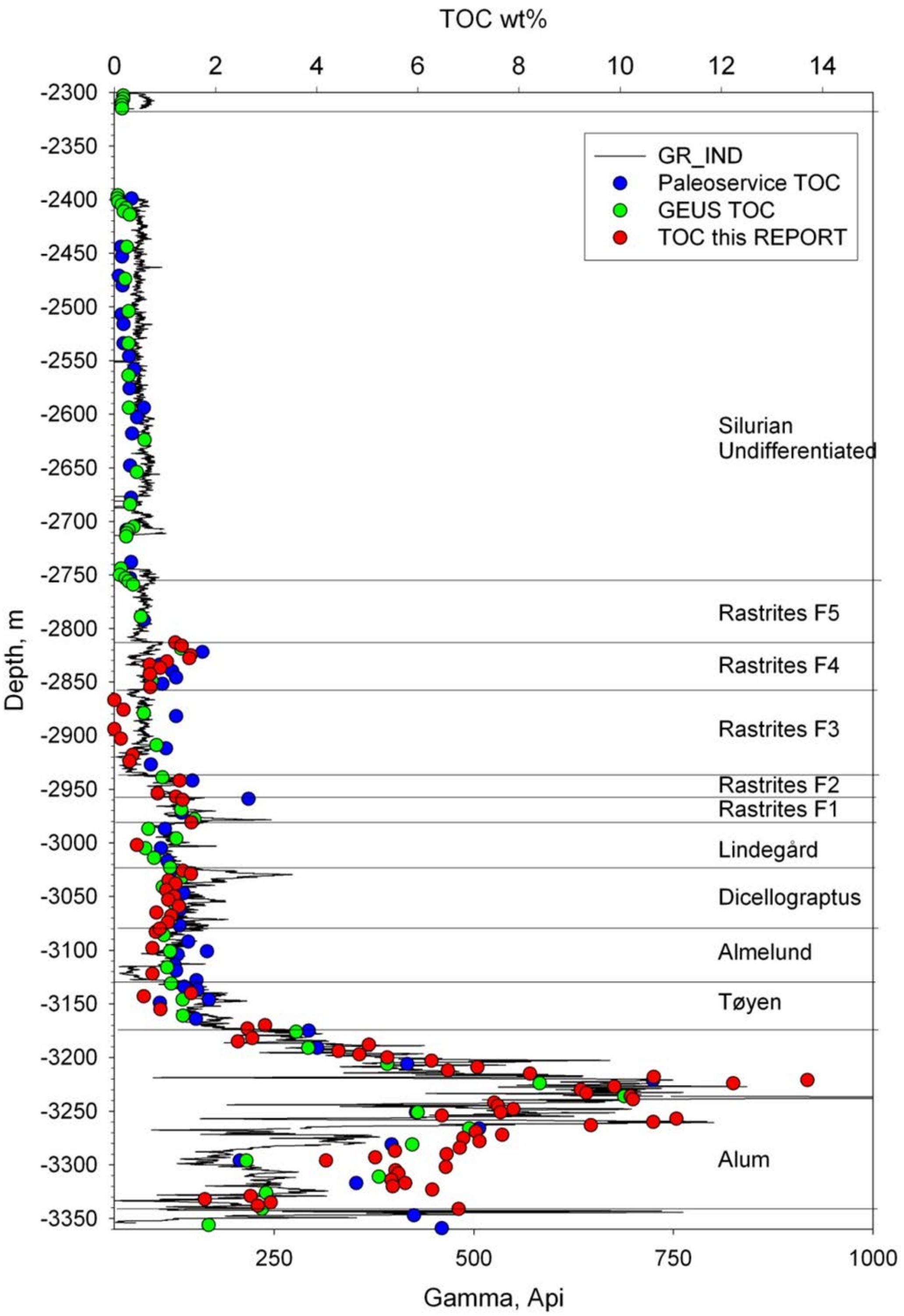

Figure 4. TOC profile in the Terne-1 well. The Gr log is shown for comparison. The TOC values in green and blue represent results from source rock screening studies summarised in Schovsbo (2011b). The samples marked with red represent analysis presented in Schovsbo (2012). The figure is an update of Figure 17 in Schovsbo (2011b).

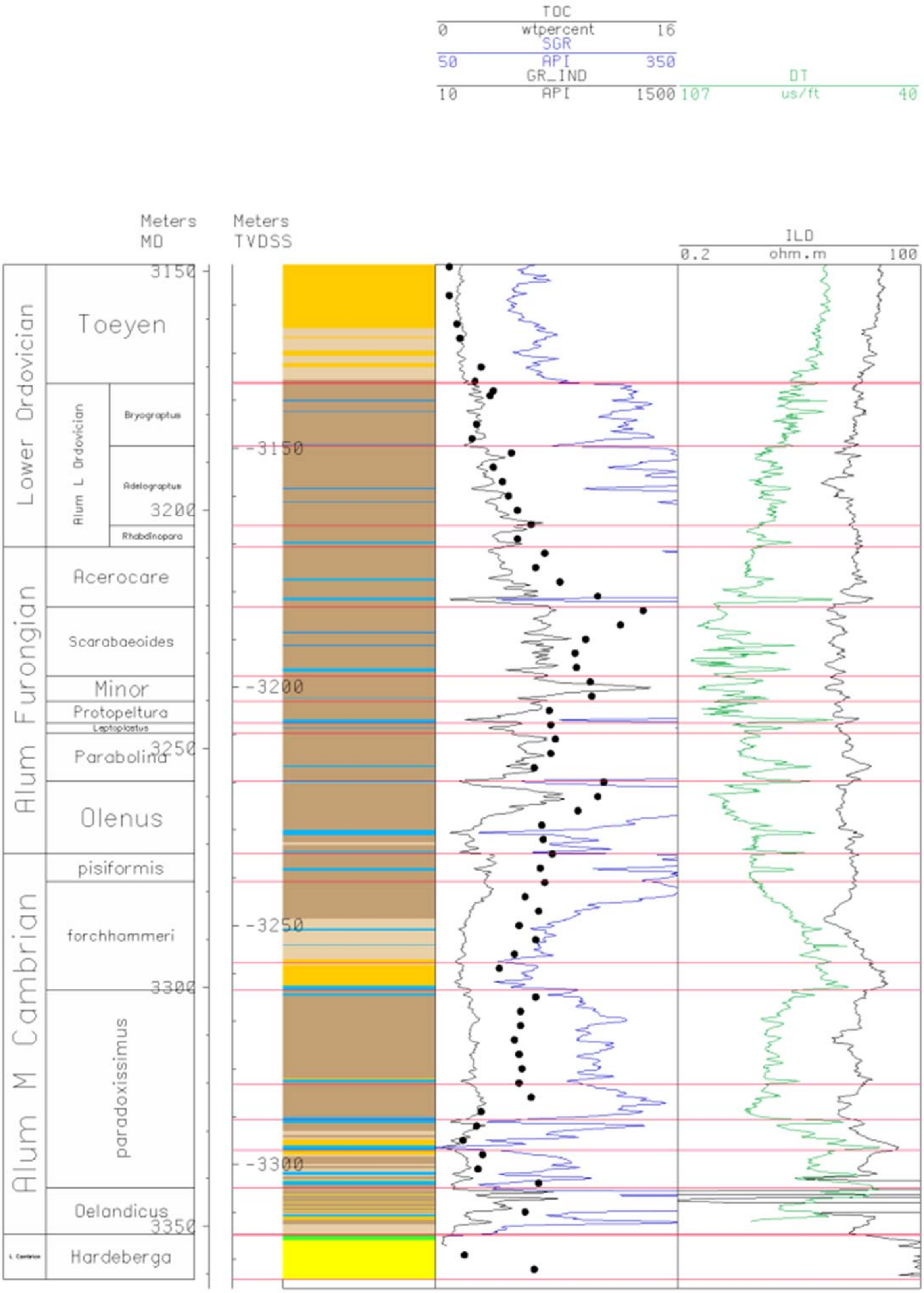

Figure 5. TOC variation in the Alum Shale Formation in the Terne-1 well. The log-stratigraphy around the basal Furongian is slightly modified from Schovsbo & Nielsen (2012). Pick depths are presented in Table 2.

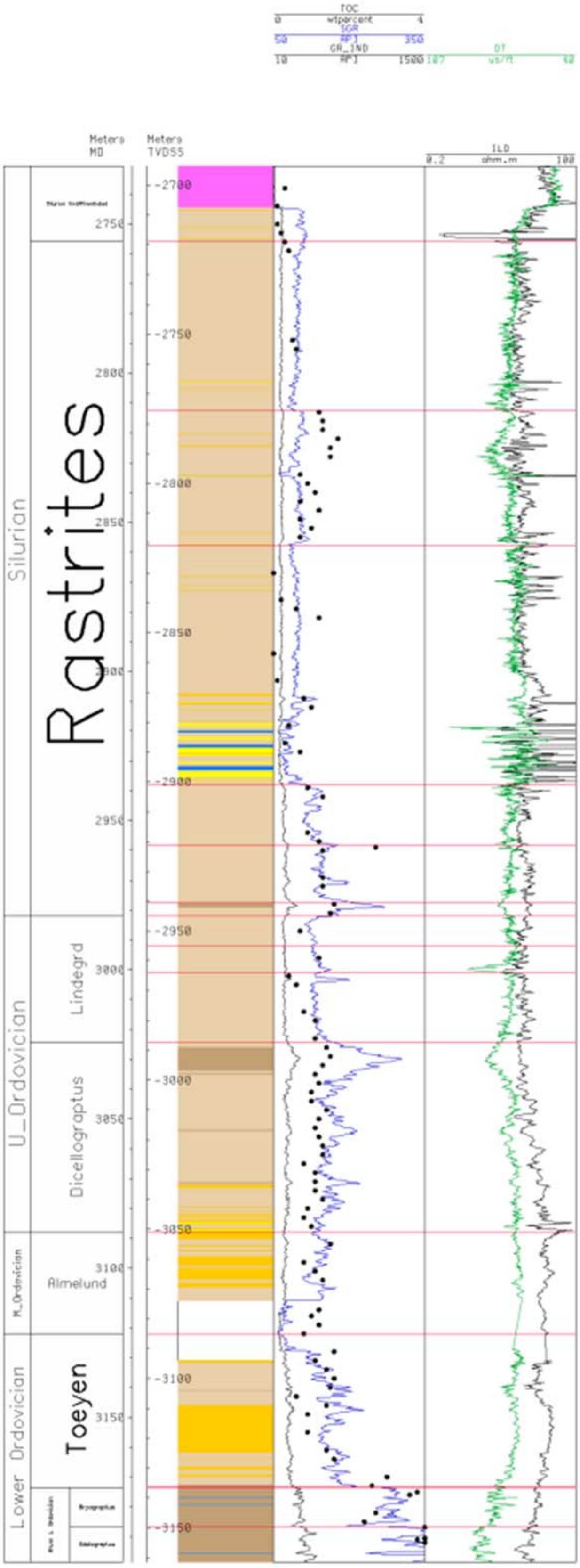

Figure 6. TOC variation in the section from the top Alum Shale and to the top of the Rastrites Shale. Note that the TOC scale is different compared to Figure 5 (from 0-4 %). The stratigraphy is after Schovsbo (2011b).

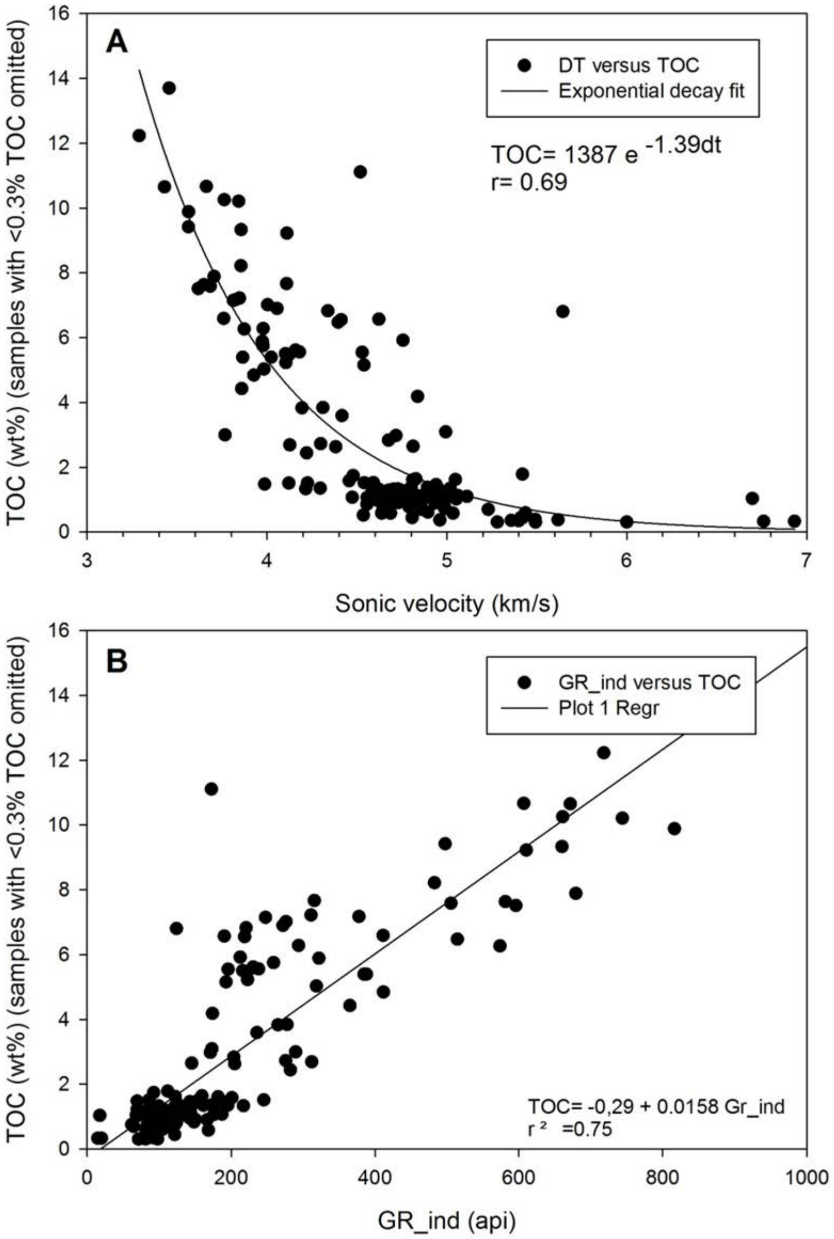

Figure 7. Relationship between TOC content and (A) sonic velocity and (B) gamma ray response in the Terne-1 well.

The TOC content is closely related to the GR response and sonic velocity and a very strong correlation between cuttings TOC and log response is evident (Figure 7).

Table 3. Stratigraphical breakdown of the TOC content in the Terne-1 well. The TOC variation in the Albjära-1 well from Schovsbo & Nielsen (2012) is shown for comparison.

Formation/age	Terne-1					Albjära-1				
	Thick, m	Avg TOC	STD TOC	Max TOC	Min TOC	Thick. m	Avg TOC	STD TOC	Max TOC	Min TOC
Rastrites F5	56.9	0.3	0.2	0.5	0.1					
Rastrites F4	44.9	1.1	0.3	1.7	0.7					
Rastrites F3	80.4	0.5	0.4	1.2	0.0					
Rastrites F2	20.2	1.0	0.2	1.3	0.9					
Rastrites F1	23.8	1.6	0.5	2.7	1.2					
Lindegård	42.1	0.8	0.3	1.2	0.4					
Dicellograptus	64.1	1.1	0.2	1.5	0.8					
Almelund Shale	35.7	1.1	0.2	1.5	0.8	105.0	1.7	0.5	2.5	0.2
Komstad Lmst	0.0					3.0	0.0			
Tøyen Shale	49.2	1.3	0.4	1.6	0.6	27.0	0.4	0.1	0.5	0.2
Bjørkåsholmen Fm	0.0					1.0	0.0			
Alum Shale:	**180.0**	**6.4**	**2.6**	**13.7**	**1.8**	**97.8**	**8.2**	**3.2**	**15.3**	**0.5**
Tremadoc	**34.1**	**4.1**	**1.2**	**6.3**	**2.4**	**7.0**	**6.2**	**2.6**	**11.8**	**0.7**
Bryograptus	13.4	3.0	0.6	3.8	2.4	3.0	4.4	2.0	7.1	0.7
Adelograptus	16.6	5.0	0.8	6.3	3.8	2.0	5.4	2.4	11.8	0.7
Rhapdinopora	4.4	5.4				2.5	6.5	2.3	11.8	1.7
Furongian	**64.5**	**9.0**	**1.9**	**13.7**	**6.5**	**58.7**	**10.1**	**2.2**	**15.3**	**4.9**
Acerocare	12.6	8.2	1.8	10.7	6.6	12.6	10.2	2.1	14.3	7.3
Peltura scarabaeoides	14.6	10.9	2.0	13.7	9.2	13.5	10.6	2.0	15.3	7.3
Peltura minor	5.4	10.2	0.0	10.3	10.2	4.1	11.5	1.7	14.3	8.8
Protopeltura praecursor	4.4	7.5				4.8	11.5	1.6	14.6	8.7
Leptoplastus	2.1	7.6				2.5	10.4	1.1	11.5	8.7
Parabolina spinulosa	10.1	7.3	0.8	7.9	6.5	9.0	7.8	1.2	10.0	5.4
Olenus	15.2	8.8	1.8	11.1	7.0	12.2	10.2	2.4	14.9	4.9
Mid Cambrian	**79.7**	**5.2**	**1.5**	**7.2**	**1.8**	**32.0**	**5.3**	**2.1**	**10.4**	**0.5**
Agnostus pisiformis	5.7	7.1	0.2	7.2	6.9	4.5	7.2	1.2	10.4	4.9
Paradoxides forchhammeri	28.4	5.7	1.0	6.8	4.2	9.8	5.9	2.4	8.4	0.7
Paradoxides paradoxissimus	51.2	5.0	1.5	6.8	1.8	17.7	4.4	1.6	7.4	0.5

3.2. Mineralogical analysis

Quantitative determination of the quartz content and semi-quantitative determination of the mineral composition have been made on 68 samples from the Terne-1 well (Schovsbo 2012). The review by Schovsbo (2011b) included analytical results of 20 of these samples. Below is an update of the figures and tables dealing with the content of quartz, feldspar and total clay. A re-evaluation of the XRD analysis is presented in Part 4 (Chapter 5) in this report. Calculated XRD compositions are presented in Appendix A.

The quartz + feldspar and the total clay content has been corrected as described in Part 4 (Chapter 5) in this report

Variation of the quartz and feldspar content

The stratigraphical variation of the quartz + feldspar content is presented in Figure 8. The quartz + feldspar content in the Alum Shale ranges between 20-55%. Lowest average contents occur in the Middle Cambrian and highest average values are measured in the Tremadoc part of the formation.

The overall stratigraphical variation in the quartz content mimics the induction log obtained in the well (Figure 8). Accordingly, quartz rich rock has a more resistive response than quartz poor rock. This interpretation of the induction log response is as expected and was also adopted in the rock type evaluation of the well (Schovsbo 2011b). In the middle part of the Middle Cambrian, however, high resistivity is measured. This increase in resistivity is not matched by a change in the mineralogical composition (Figure 8).

In the Furongian the lowest and highest content of the quartz +feldspar have been measured for the formation (Figure 8). Very low quartz + feldspar content occur in the lower part of the Furongian (essentially the *Olenus* Zone). In the upper part of the Furongian consistent high values are measured. This level coincided with a change in resistivity in the formation at 3210 m (Figure 8). A few samples show relative high quartz + feldspar suggesting that some of the high resistive beds in the Alum Shale might be quartz rich. The high resistive beds in the Furongian have hitherto been interpreted to reflect the presence of carbonate beds and nodules (Schovsbo 2011b).

In the Ordovician and Silurian shales the quartz + feldspar content ranges between 40-65% (Figure 8). Quartz and feldspar rich samples occur in the Rastrites Shale indicating that some of the high resistive beds may be quartz rich.

Comparison to Scania and Bornholm

High resolution profiles of the quartz content in the fully cored Alum Shale wells from Scania and Bornholm has not been made and thus the occurrence of quartz rich beds is poorly known. The increase in quartz content seen in the Tremadocian part of the Alum Shale is, however, also evident in the Skelbro-2 and Billegrav-2 wells on Bornholm.

The quartz profile in the Billegrav-2 well indicates that quartz rich beds do occur within TOC rich intervals such as in the Dicellograptus and Rastrites shales. These newly documented beds are interpreted to have been deposited during highest sea-levels. More detailed studies of the genesis of these beds including studies of thin section are currently being carried out.

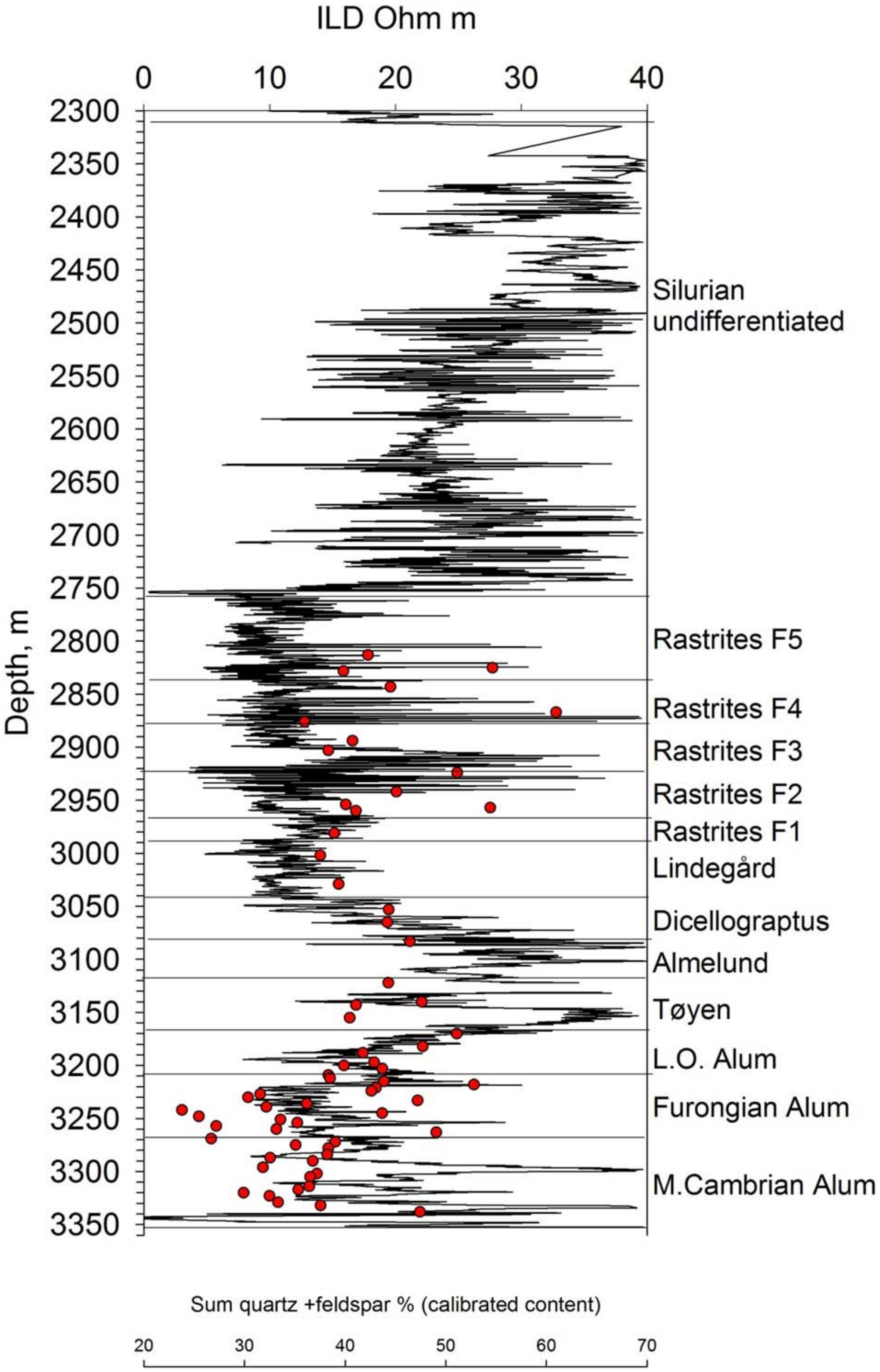

Figure 8. Stratigraphical variation of the quartz + feldspar content in the Terne-1 well. The ILD log curve is shown for reference.

The quartz + feldspar content exhibits an overall decrease with increasing TOC content (Figure 9a). A clear stratigraphical grouping of the samples can, however, be seen and each stratigraphical group defines trends with increasing quartz + feldspar content with increasing TOC content (Figure 9a).

The brittleness index versus the TOC content can also be broken down into several stratigraphical groupings suggesting that the brittleness index also increases with increasing TOC content (Figure 9b).

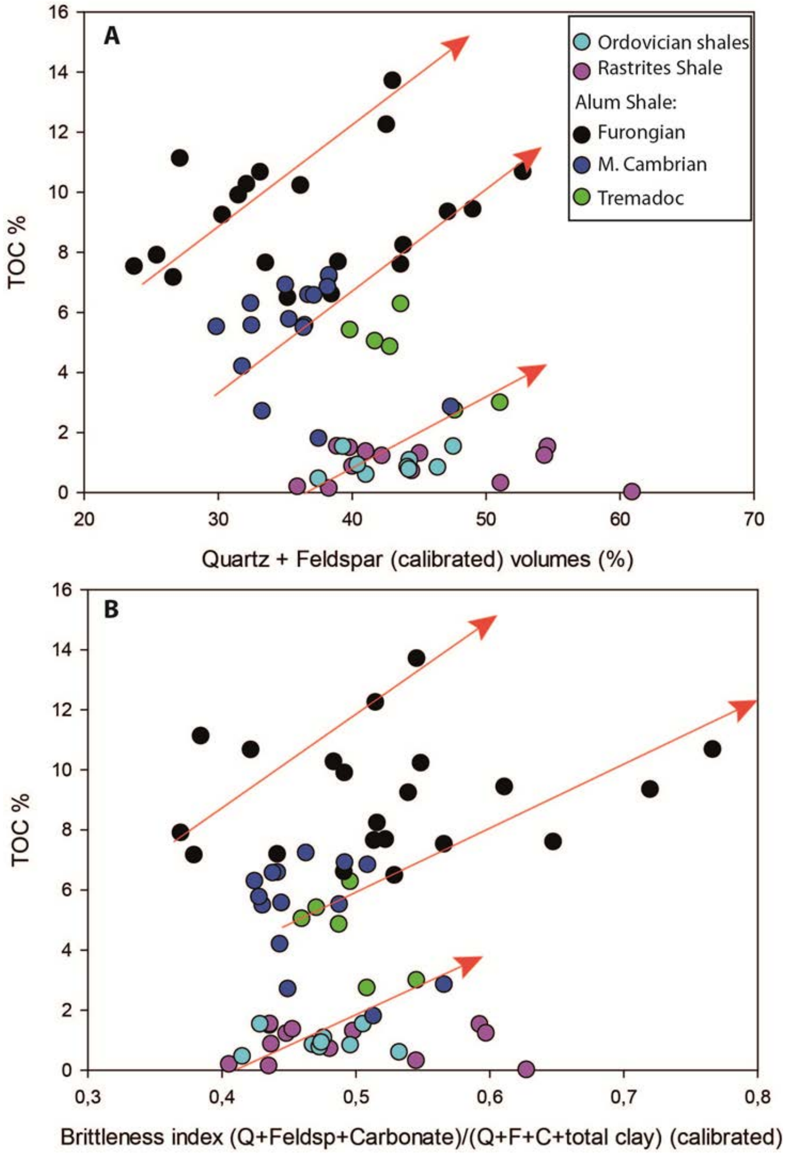

Figure 9. Stratigraphical breakdown of the relationship between the TOC and (A) the content of quartz + feldspar and (B) the brittleness index. The arrows indicate general trends in the dataset defined by stratigraphical age.

4. Part 3 Chemostratigraphy of the Lower Palaeozoic interval in the Terne -1 well

A high resolution gamma-log based correlation between the Terne-1 well and the fully cored and biostratigraphical dated wells in Scania have been established by Schovsbo & Nielsen (2012) for the Alum Shale. To further strengthen this correlation and to provide additional means for correlation in the Lower Palaeozoic sequence above the Alum Shale 100 cutting samples were analysed for their trace element composition and carbon isotope signature in the Terne-1 well. The samples cover all cutting intervals in the Alum Shale whereas not all cutting intervals were analysed in the Lower Palaeozoic interval above the Alum Shale.

The chemostratigraphical analysis of the Terne-1 well is presented in Figures 12, 14, 15 and 16. The resulting correlation to the Scanian Gislövshammar-2 well is presented in Figure 10. The chemostratigraphical analysis has confirmed the gamma log based correlation presented in Schovsbo & Nielsen (2012) and only minor updates have been made to accommodate the new chemostratigraphical information. The updated stratigraphical picks for the Terne-1 well are presented in Table 2.

Reference curves

The reference curves for the chemostratigraphical analysis of the Terne-1 well is the trace and major element profiles from the Gislövshammar-2 well (Figure 11, Schovsbo 2001, 2002) and δ^{13}C profiles from the Albjära-1, Gislövshammar-2 and Billegrav-1 wells (Schovsbo 2002b). For the sedimentary geochemistry the reference sections presented in Schovsbo (2003) from Scania/Bornholm and for the Oslo area are used (Figure 13).

The reference curves have a poor stratigraphical resolution in the section above the Alum Shale. This circumstance combined with the fact that the Terne-1 well also was analysed with a low stratigraphical resolution means that only geochemical variation related to long term environmental changes in the isotopic record or to shifts in provenance areas have been detected. Better reference curves for the time interval can be established by performing additional chemostratigraphical data for the Albjära-1, Lönnstorp-1 and Billegrav-2 wells. Additional samples from the Terne-1 well will also increase the stratigraphical resolution.

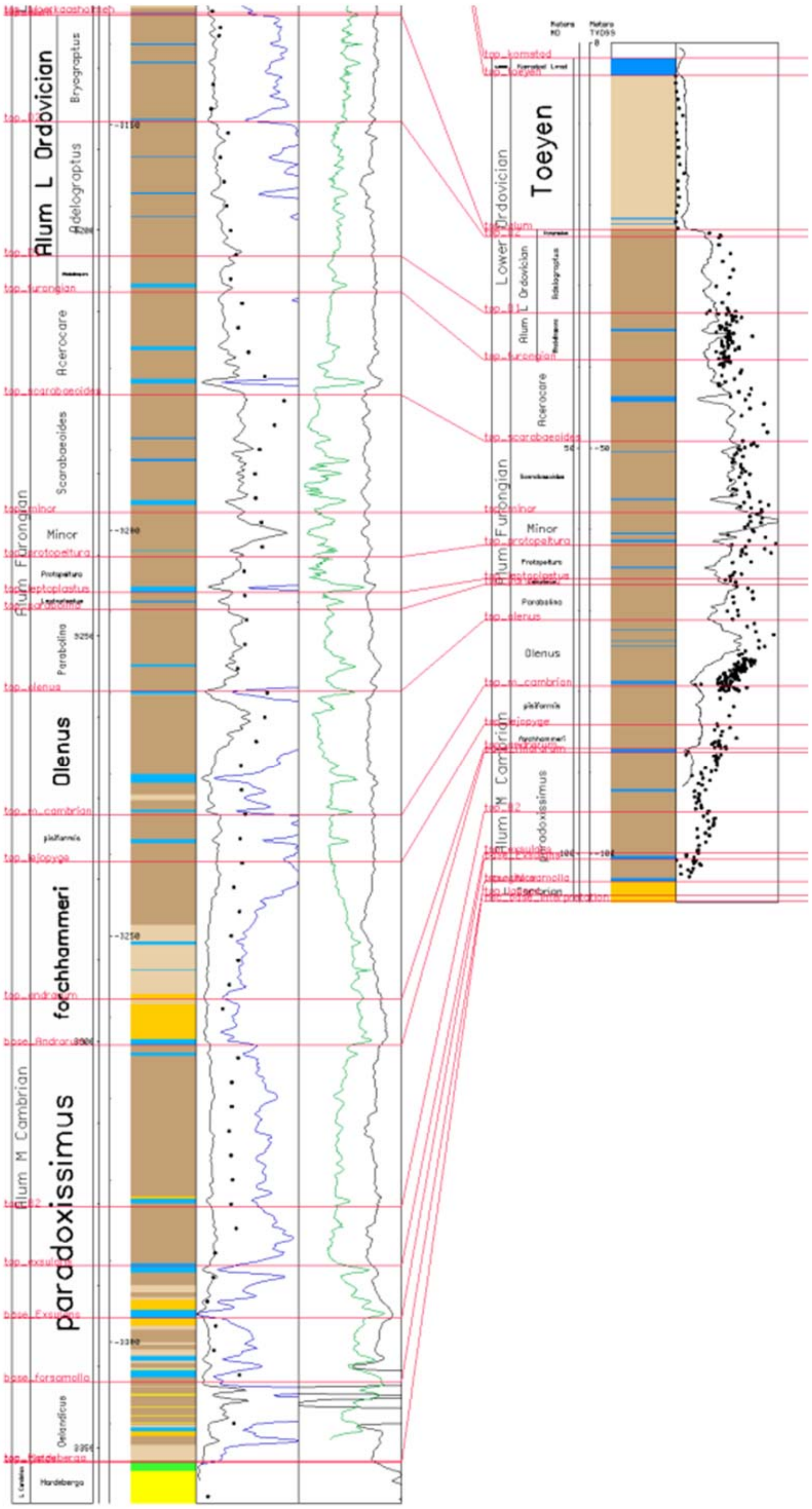

Figure 10. Correlation between the Terne-1 well (left) and the Gislövshammar-2 well (right). The pick depths are presented in Table 2. Note that there is a slight update in the basal part of the Furongian compared to the interpretation presented in Schovsbo & Nielsen (2012) due to the incorporation of chemostratigraphical information.

4.1. Trace elements

The Alum Shale is enriched in redox sensitive elements (i.e. V, Mo, U) and elements that form insoluble compounds with sulphide (i.e. Ni, Cu, Co, Pb) as is commonly observed in many black shales. The element distribution has a very strong stratigraphical component which has been ascribed either to source availability, to specific compounds acting as sinks for the elements or to the depositional environment that favours accumulation of specific elements relative to other elements (Schovsbo 2001, 2002a).

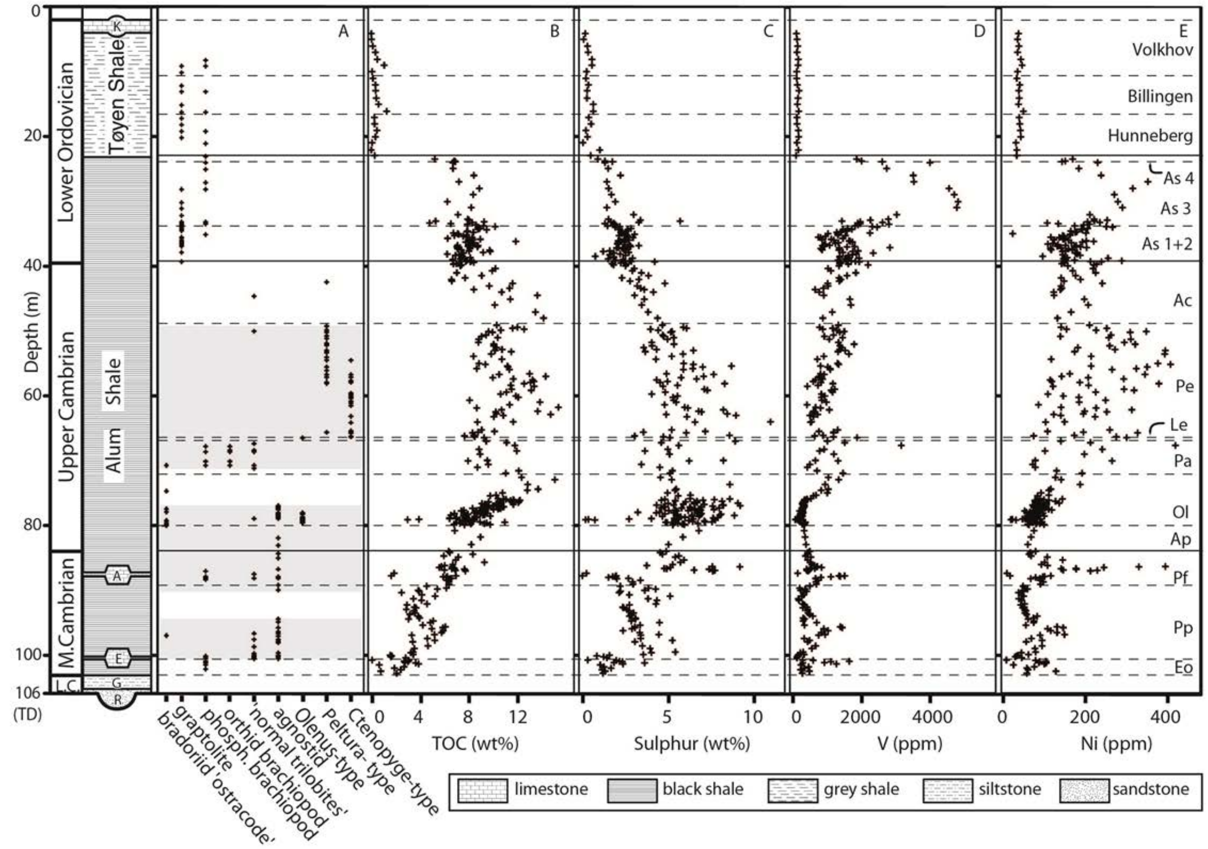

Figure 11. Geochemical reference profiles for the Alum Shale based on analyses from the Gislövshammar-2 well (Schovsbo 2001).

Vanadium enriched intervals

A high resolution profile of the V content was presented by Schovsbo (2001) who also presented a geochemical model of the enrichment of V relative to Ni in the Alum Shale.

In the Alum Shale there is a pronounced V enrichment in the middle to upper part of the Tremadocian. This enrichment is traceable in many parts of the basin and even in the Caledonian mountain chain in Norway (Schovsbo 2001). V enriched intervals occur, however, also in the lower part of the formation and are related to changes in the depositional environment. Enrichment of V is seen preferentially in shale deposited during upper dysoxic conditions at the sea-floor whereas shale deposited during anoxic/euxinic conditions tends to have low V content (Schovsbo 2001).

Identified V enriched intervals in Terne-1 and Gislövshammar-2 and correlations based on the V-content (Figure 12):

Middle Cambrian
Just below the Exsulans/Forsemölla Limestone
In the Middle part of the Paradoxides paradoxissimus
In the *Lejopyge lavigata* Zone

Furongian
The uppermost part of the *Olenus* Zone
In the *Parabolina* Zone
In the *Peltura scarabaeoides* Zone

Tremadoc
The *Adelograptus* interval (the As 3 zone in Figure 11)
The *Bryograptus* interval (the As 4 zone in Figure 11)

Uranium enrichment intervals

Most of the variation in the U content is captured by the gamma log curve since the gamma emission is much higher for U compared to K and Th in black shales. The logstratigraphy of the Alum Shale in the Terne-1 well has already been presented in Schovsbo & Nielsen (2012) and indicate that the distribution of U can be used for correlation even between wells located several hundreds of kilometres apart.

Schovsbo (2002) argued that the U enrichment varies laterally in the basin with a relative enrichment in the shoreward parts of the basin as compared with the deeper parts of the basin. In addition the enrichment occurs in depositional environments characterised by relative low oxygen content probably in the anoxic/euxinic regime. The U enriched shales is thus in theory not characterised by a V enrichment also. This is also the general case in the Alum Shale (Figure 12) where the V enrichments tend to occur stratigraphically above or below profound U enrichments.

The most significant U enriched intervals suitable for correlation are (Figure 12):

Middle Cambrian:
In the upper Middle Cambrian a high uranium interval is corresponding broadly to the upper *Lejopyge lavigata* and the *A. pisiformis* zones

Furongian
The upper *Olenus* Zone high uranium interval
The *Parabolina* Zone high uranium
The *Peltura minor* uranium rich interval that records the highest level of radioactivity in the formation

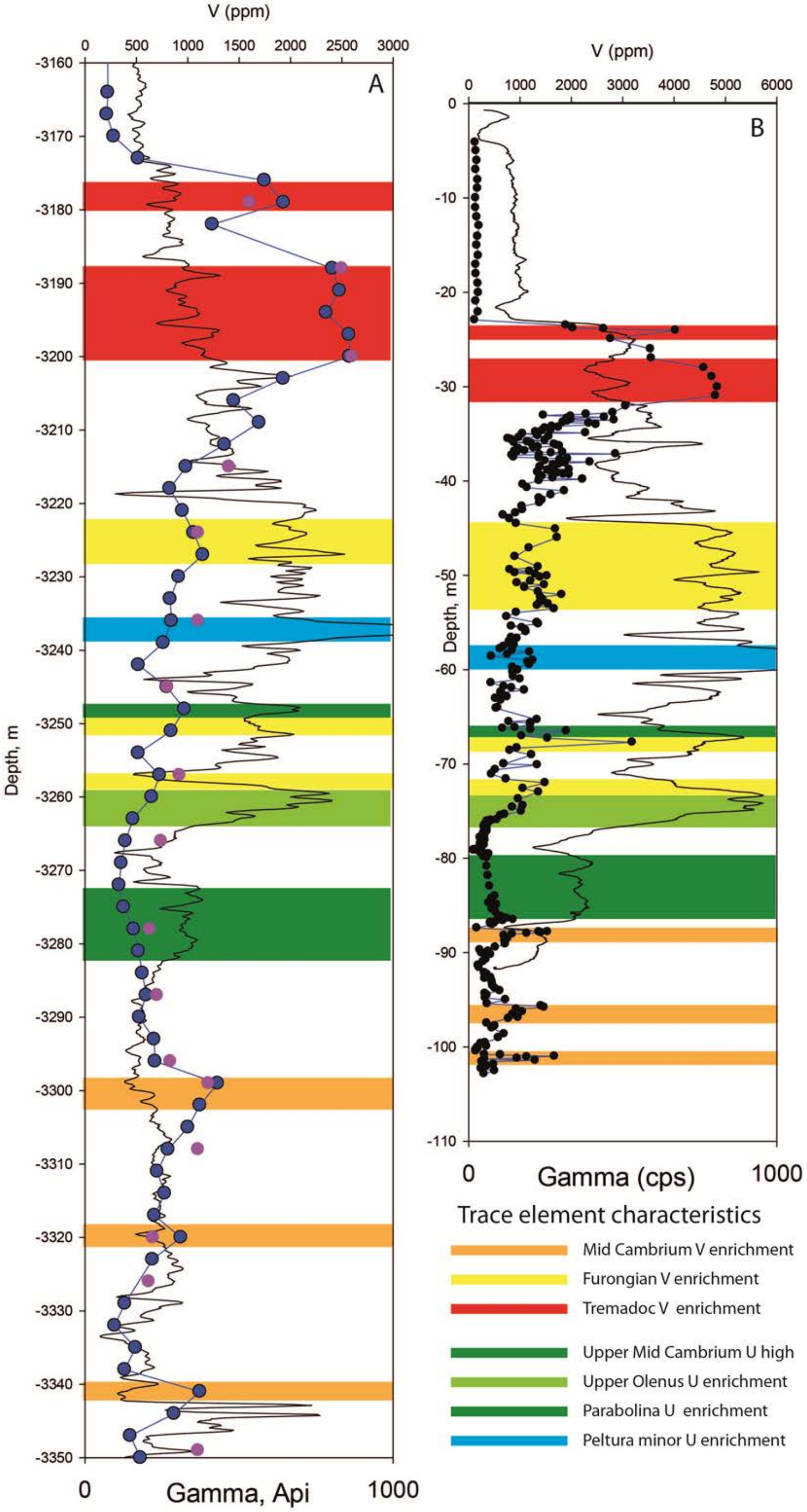

Figure 12. Vanadium and gamma ray (uranium) profiles for (A) the Terne-1 well and (B) the Gislövshammar-2 well. In (A) the blue filled circles represent analyses presented in Schovsbo (2012) and the pink filled circles represent archive data presented in Schovsbo (2011b). The data in (B) is from Schovsbo (2001, 2002a).

Geochemical changes related to shifts in provenance

Schovsbo (2003) investigated the long term variations in the geochemical composition related to changes in source area induced by the Caledonia orogeny. In the Upper Ordovician the geochemical composition of the sediments change towards a composition more alike immature oceanic arc derived sediments (Figure 13). The introduction of this new source area is also heralded by an acceleration of the depositional rates both in the Oslo area and in the Scania/Bornholm area (Schovsbo 2003).

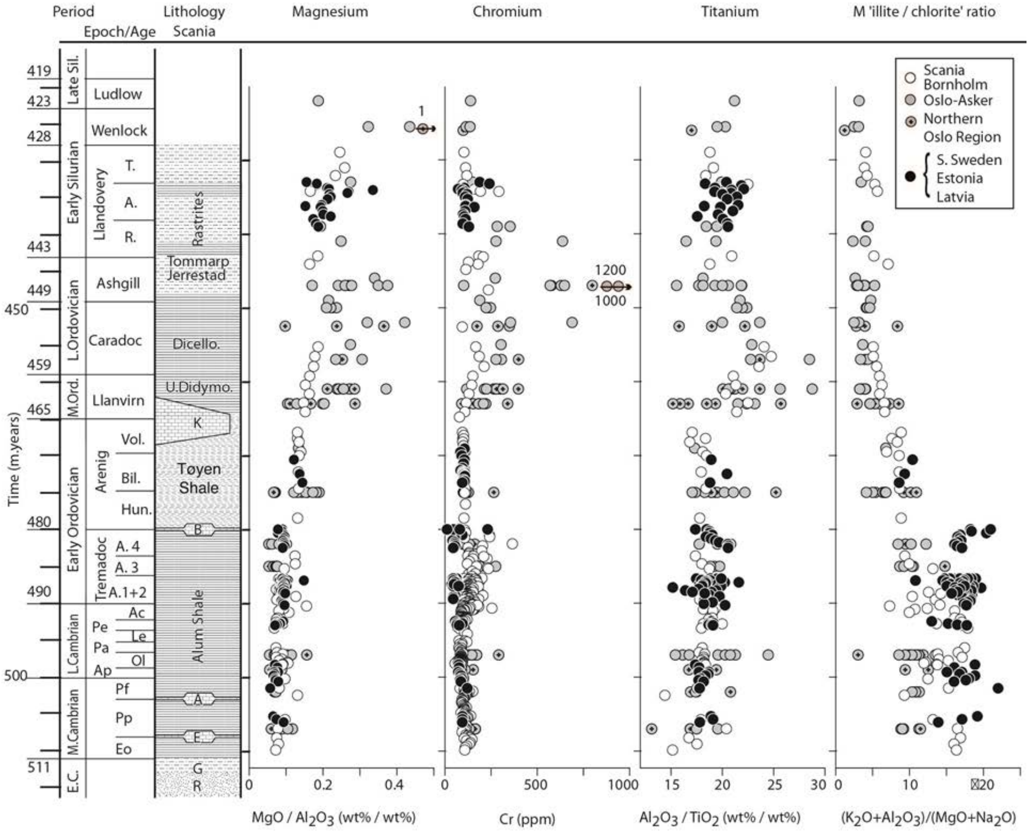

Figure 13. Geochemical reference profile for Lower Palaeozoic sediments deposited on the margins of Baltica (from Schovsbo 2003).

Key features in the sedimentary geochemistry identified in the Terne-1 well (Figure 14):

The Tremadoc Cr enrichment (coinciding with the Tremadoc V enrichment)

The Upper Ordovician – Lower Silurian high Cr interval

Silurian high Cr interval

This enrichment in Cr is not identified in Scania/Bornholm but is present in the Oslo area (Schovsbo 2003).

Mid Ordovician to Lower Silurian change in the sediment maturity 'M'

The parameter 'M' ((K+Al)/(Mg+Na)) is a proxy for sediment derived from cratonic sources relative to oceanic arc derived sediments (Figure 13). The ratio exhibits overall low values in the Upper Ordovician to Silurian as a consequence of changes in the sediment maturity (Figs 13 and 14).

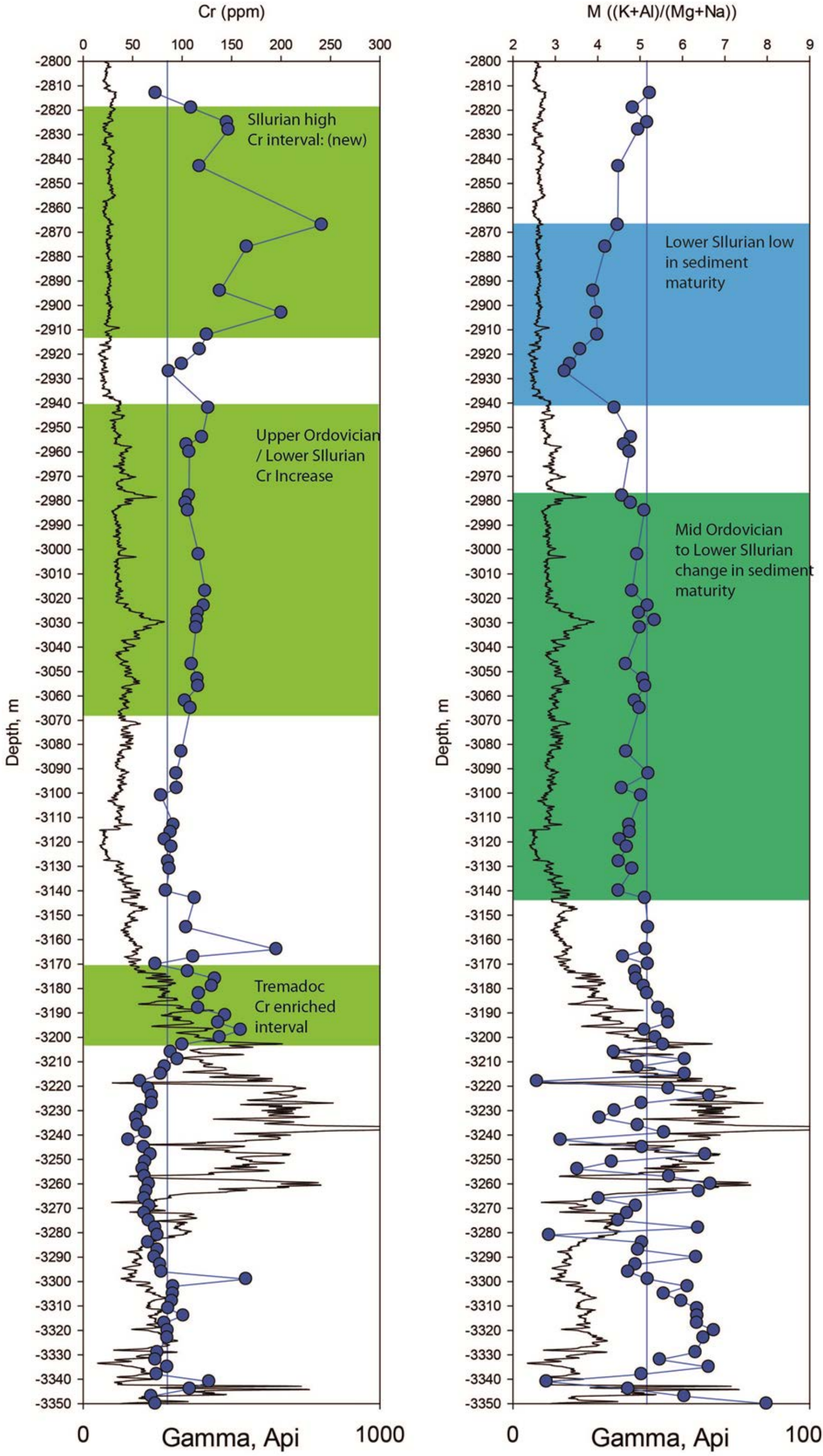

Figure 14. Profile of (left) the chromium content and (right) the sediment maturity parameter 'M' ((K+Al)/(Mg+Na)) for the Terne-1 well. The gamma ray curve is shown for comparison.

4.2. Carbon isotopes

Carbon isotopes measured on organic carbon on bulk samples is a very robust tool for undertaking chemostratigraphical correlation. The variation in isotope signatures records the composition of the sea-water that reflects global changes in the removal rate of carbonate carbon (positive δ^{13}C values) versus organic carbon (negative δ^{13}C values). Carbonate carbon dissolved in sea-water during periods with relative high removal rate of carbonate carbon (caused by carbonate precipitation or by addition of weathered organic carbon) will thus be relatively more negative compared to periods with relatively high removal rate of organic carbon.

Isotope variation in the Alum Shale

The distinct carbon isotope variation in the Alum Shale is very well suited for chemostratigraphical correlation due to its very characteristic variation recognisable in many parts of the basin (Schovsbo 2002b). During the Middle Cambrian the δ^{13}C values became progressively heavier and in the Furongian to Tremadoc intervals the isotopic signature undulated slightly around a grand mean of -29.5 o/oo V-PDB (Figure 15).

The Gislövshammar-2 reference curve for the Alum Shale (Figure 15) is not analysed with similarly high resolution as for the trace elements and thus the details in the variation in the carbon isotopes are not known. Currently a high resolution study of the δ^{13}C variation in the *Peltura* zones in the nearby Fågeltofta-2 core is being analysed. That study will also investigate the feasibility of the δ^{34}S isotope variation as a chemostratigraphical indicator.

Carbon isotope events identified in the Terne-1 well and in the Gislövshammar-2 well and the correlation based on the isotope variation (Figure 15):

<u>Middle Cambrian</u>
B2 event: An interval within the middle Cambrian B2 trilobite zone characterised by relatively negative carbon isotopes. Gradually more positive carbon isotopes are seen in the shale above the B2 event.

B4 event: An interval in the B4 zone characterised by relatively positive δ^{13}C values.

<u>Furongian</u>
*The SPICE positive carbon isotope excursion (*Saltzman et al. 1998*).* During SPICE the most prominent positive δ^{13}C signal of the formation developed and the event is easily identified in the Terne-1 isotope profile (Figure 15).

In the Gislövshammar-2 the SPICE occurs in the lower *Olenus* Zone (Schovsbo 2002b) below the upper *Olenus* Zone uranium maximum (Figure 14). The same pattern is evident in the Terne-1 well.

The Parabolina negative carbon isotope excursion marks the return to pre-SPICE values.

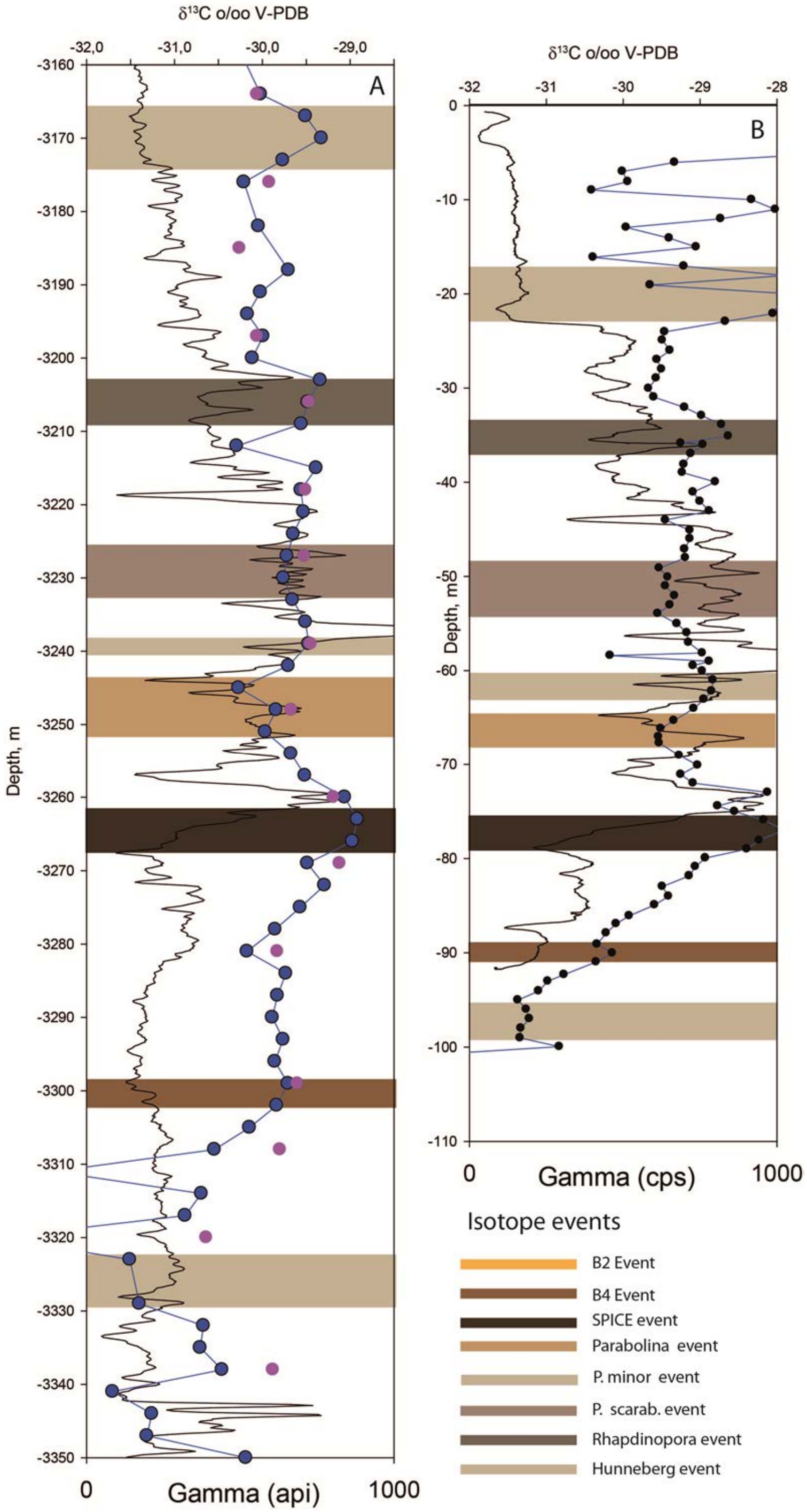

Figure 15. Correlation between (A) the Terne-1 well in the interval 3160-3350 MD and (B) the Gislövshammar-2 well based on the stratigraphical variation of carbon isotopes. Fill colour: blue analysis from Schovsbo (2012), pink: archive data in Schovsbo (2011b). The gamma ray curves for the wells are shown for comparison.

The Peltura minor positive carbon isotope excursion occurs just below the very pronounced U enrichment in the mid to upper *Peltura minor* Zone. The combination of the carbon isotope excursion and the U-enrichment makes this a very strong chemostratigraphical marker.

The *Peltura scarabaeoides* event marks the return to pre-excursion values.

Tremadocian

Rhapdinopora positive carbon isotope event. An interval characterised by a marked change in $\delta^{13}C$ signatures towards more positive values. The section above the event is characterised by slightly more negative $\delta^{13}C$ signatures.

Carbon isotope correlation in the shales above the Alum Shale interval

The most marked carbon isotope event in the Ordovician is the Hirnantian positive carbon isotope event (e.g. Hammarlund et al. 2012) and it was expected that it would be a prominent feature in the isotope record in the Terne-1 well. However, it is uncertain where this event is located (Figure 16). It is possible that it has been missed by the analytical programme (too large distance between samples) or that cuttings, with some degree of mixing, are unsuitable for analysis.

Nevertheless, the most positive isotope signature measured in Terne-1 well is at 3050 m which potentially could be the Hirnantian isotope signature. Alternatively, the Hirnantian isotope signature is within the interval between 2985 and 3020 m characterised by slightly positive isotope signatures. This interpretation is favoured by the assumed identification of the negative isotope excursions (rather return to pre-excursion values) between 2970-2980 m and 3020-3035 m (Figure 16). If this is correct then the gamma log correlation is confirmed for this interval.

The other marked feature in the isotope record in Scania is an interval in the Tøyen Shale just above the top of the Alum Shale that is characterised by positive $\delta^{13}C$ signatures (Figure 16). This interval could correspond to the positive isotope interval around 3170 m in the Terne-1 well (Figure 16). Again this correlation is predicted from the gamma log based correlation. However, analysis of a profile with high stratigraphical resolution is recommended to be made in the Almelund shale in the Albjära-1 in order to have a better resolution of the isotope variation in this interval.

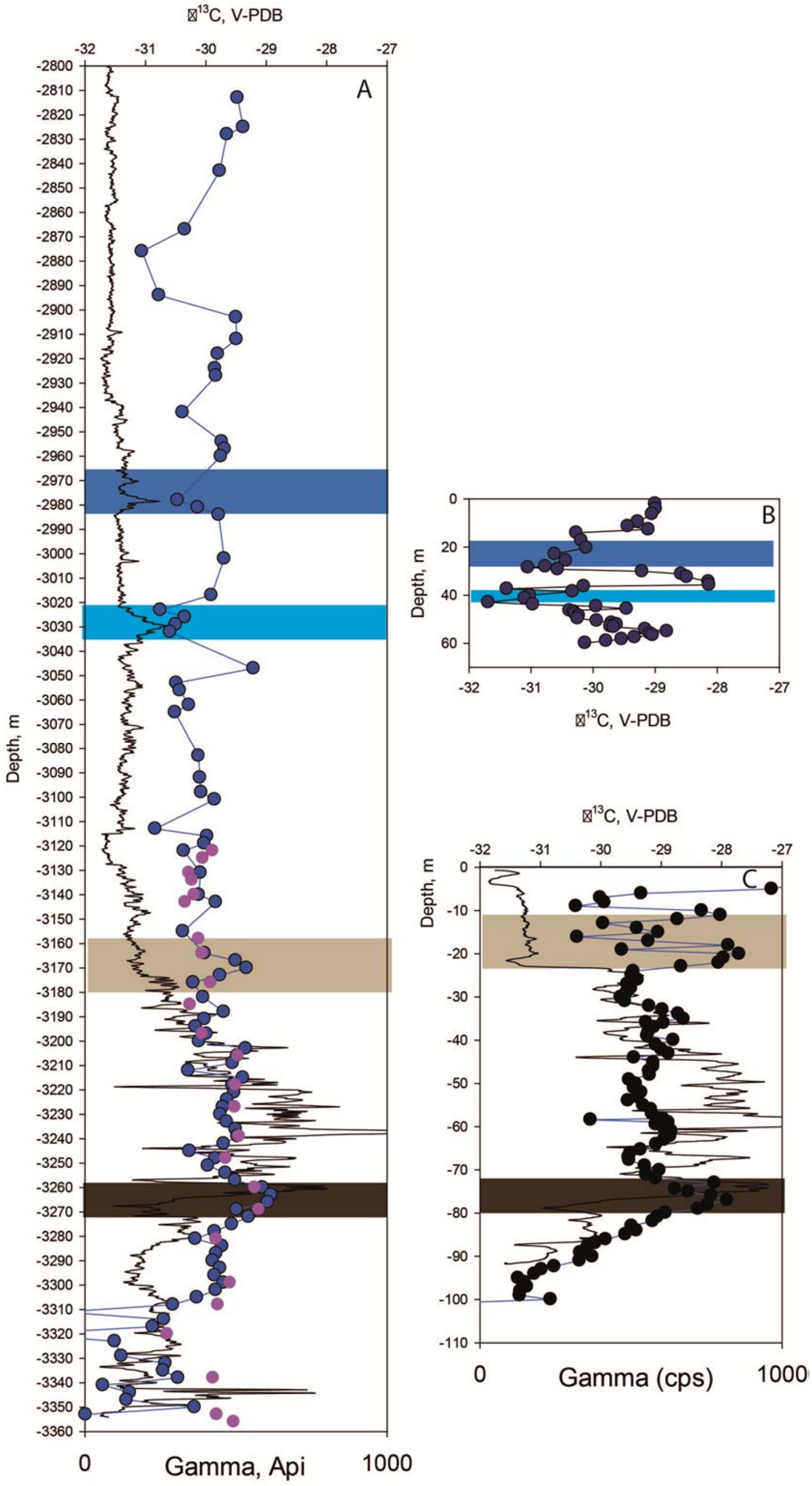

Figure 16. Correlation of the interval above the Alum Shale based on the stratigraphical variation in carbon isotopes for (A) the Terne-1 well, (B) the Billegrav-1 well and (C) the Gislövshammar-2 well. In (A) the fill colours are blue: carbon isotope analysis in Schovsbo (2012), pink: analysis in Schovsbo (2011b). The Gr curves for the wells are shown for comparison. The data in (B) is from Buchardt et al. (1986) and the data in (C) is from Schovsbo (2002a, 2002b).

5. Part 4 Comparison of XRD results from three laboratories

The mineralogical composition of 20 samples from the Terne-1 well has been the subject of an intra-laboratory comparison between the GEUS clay laboratory, the XRD laboratory at the Geological Museum, University of Copenhagen, and a XRD laboratory chosen by TOTAL E&P (RGM). The aim of the comparison was to achieve consistency of the analytical results especially focused on the quartz+ feldspar ratio and the total clay content and the calculated brittleness index (Q + C + F) / (Q + C + F + Total Clay).

GEUS data

The analytical results of the 20 samples analysed by GEUS clay laboratory were presented in Schovsbo (2011b). As part of this data evaluation the GEUS laboratory was asked to re-interpret the XRD spectra obtained on the samples. It was found that for some of the samples the feldspar content was not reported in Schovsbo (2011b). Consequently an updated version of the data tables is provided in Table 4 and calculated concentrations are presented in Appendix A of this report. The updated data is termed the GEUS August 2012 data.

The GEUS data is semi-quantitative and relies on calibrated standards and/or quantitative measurements. In the data quantitative measurements of carbonate, pyrite, and organic carbon content and a calibrated XRD standard for the quartz content was used (Schovsbo 2011b). Total clay content was calculated assuming that all non-clay phases were measured. Accordingly the method will tend to overestimate the total clay volume since all un-determined components will be calculated as clays.

Geological Museum data

The Geological Museum data was presented in an analytical report from the XRD laboratory leader Tonci Balic-Zunic (Appendix B in Schovsbo 2012). The samples were measured by XRD diffraction with a quantitative Rietveld phase analysis. The Rietveld method (Topas 4 program, Bruker-AXS product) was used for calculating the mineral quantities.

The TOTAL E&P data (RGM)

The (RGM) data was made available by TOTAL E&P is presented in Table 5. The analyses were made on the remaining rock powder. This amount was generally below 2 g. The RGM data was determined by XRD diffraction technique.

Comparison of the analytical results

In Table 5 a comparison of the results of the three laboratories are presented and in Figures 18-19 the stratigraphical variations of the total clay and the brittleness index are shown. There is obviously a good correspondence between the Museum and RGM analytical results. This is evident both regarding the calculated average contents for the well and stratigraphical variation (Table 5). The difference in total average clay content in the well is 2.5% (% units) and 0.2% (% units) for the average quartz content between the two laboratories.

The GEUS August 2012 data reports significantly higher clay content and lower quartz content (Table 5). From the stratigraphical variation it is obvious that there is a systematic offset between the data and that this is not related to analytical precision rather than to the difference in methods applied by the laboratories.

Calibration of the quartz + feldspar content (Figure 17)
The difference in concentration between the GEUS August 2012 data and the Geological Museum data stems from a systematic difference in the measured total quartz + feldspars content (Figure 17) and probably relate to the fact the feldspar content in the GEUS data sat was not calibrated to a known standard.

In order to correct for this the Geological Museum data (as confirmed by the RGM data) has been used to correct the GEUS data by utilising the strong correlation shown in Figure 17. This correction has been used to correct the data in Table 5 in the column 'GEUSCorr'. The average Total clay for the well is for the GEUScorrected data 42% (39-43% for RGM and Museum) and the quartz+ feldspar content is 37% (35% for both RGM and the Museum).

The brittleness index (Figure 19)
The average index for the Terne-1 well is 0.52-0.51 for the RGM and Museum data (Table 5). For the GEUS August 2012 data the index was as low as 0.44 for the well. By correction of the quartz+ feldspar content the average index calculated from GEUScorrected is 0.52.

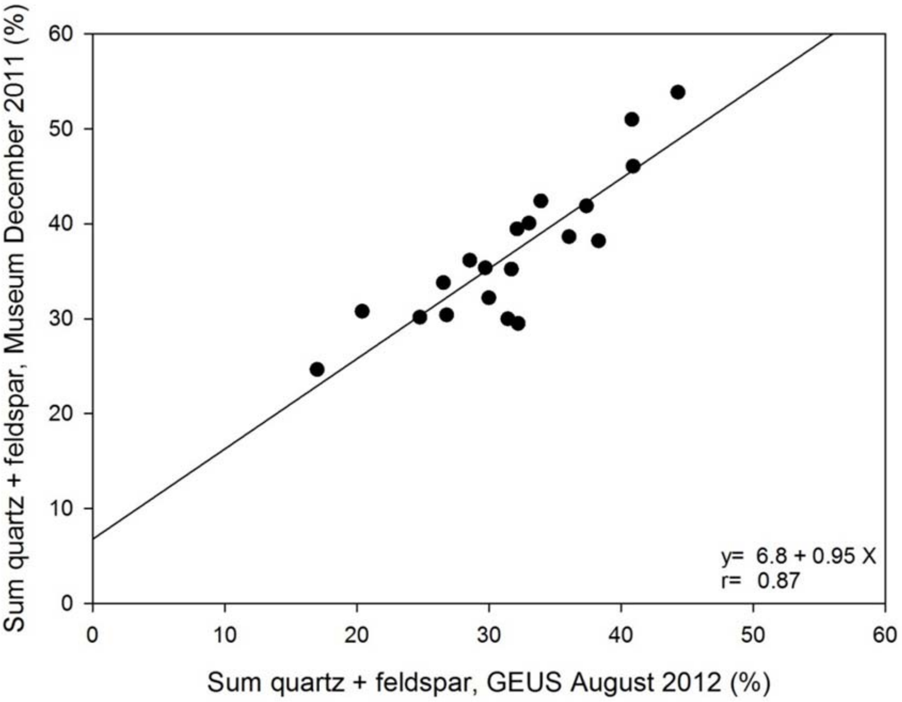

Figure 17. Comparison between the quartz + feldspar content in the GEUS August 2012 data (Appendix A in this report) and the quartz + feldspar content in the Geological Museum data (Appendix B in Schovsbo 2012). The two parameters are strongly correlated. Based on this correlation analysis the quartz + feldspar content in the GEUS August 2012 data have been corrected.

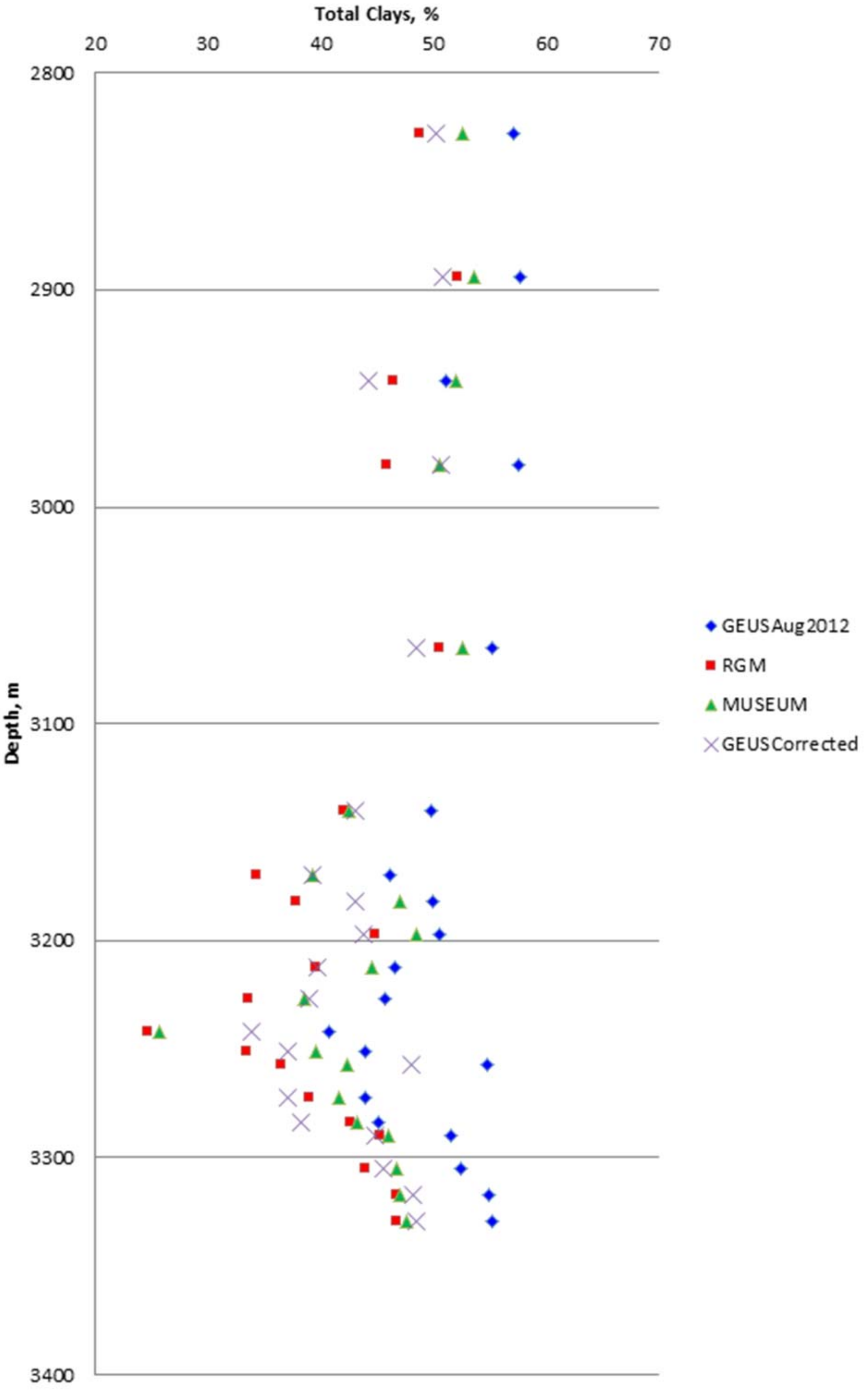

Figure 18. Stratigraphical variation of the total clay content. The Museum and RGM data exhibit similar trends. The GEUS August 2012 data is systemically offset to higher values. The GEUS corrected data has been adjusted for this off-set.

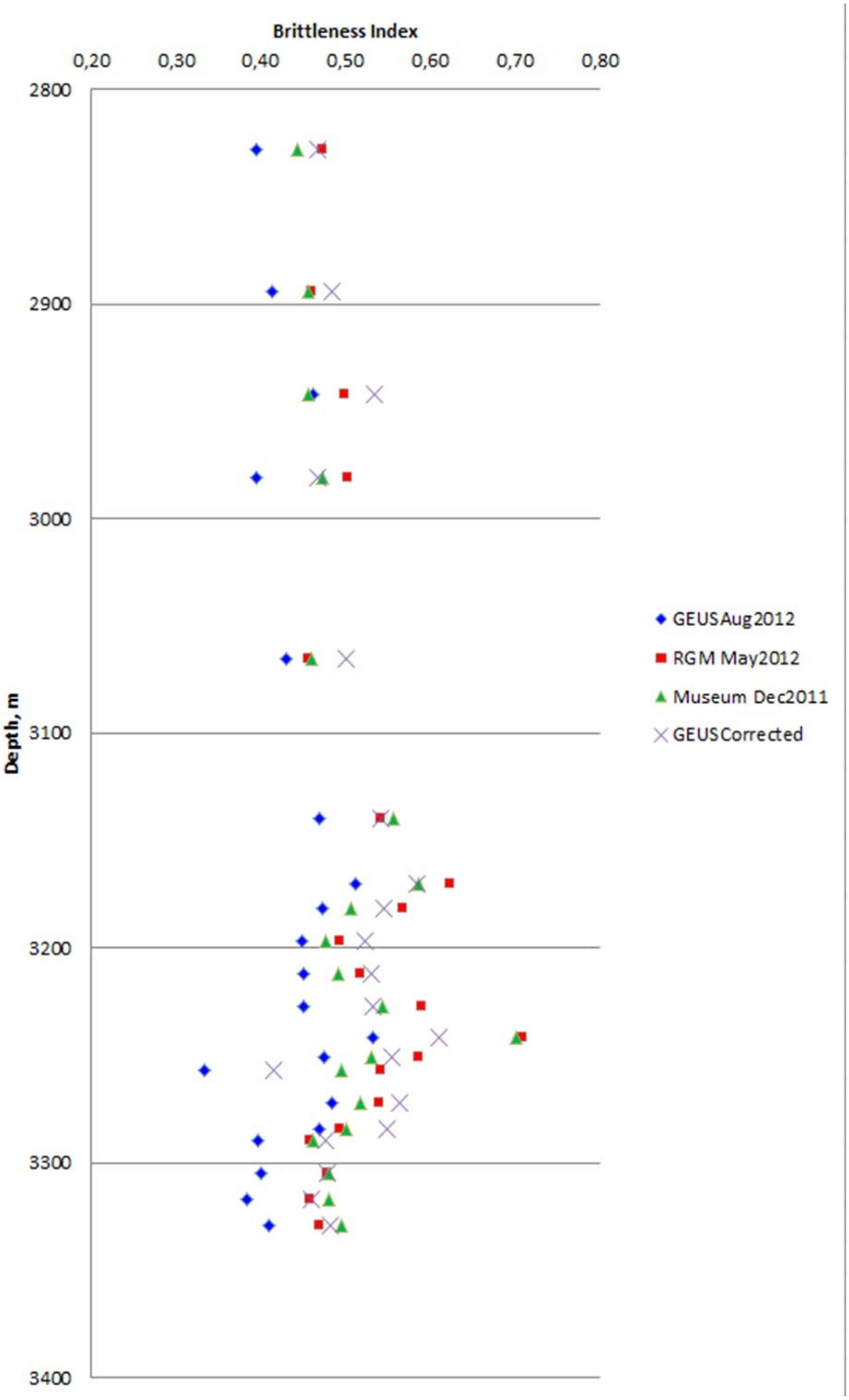

Figure 19. Stratigraphical variation of the brittleness index. The Museum and RGM data exhibit similar trends. The GEUS August 2012 data is systemically offset towards lower values. The GEUS corrected data has been adjusted for this off-set.

Table 4. Mineralogical composition of the Terne-1 samples. Numbers refers to Peak height. The table replaces table 5 in Schovsbo (2011b). The data is referred to as GEUS August 2012.

Unit	Depth	Kaolinite	Mica	Clay	Q	Plag.	Calcite	Pyrite / Marcasite	Dolo/ Anke
		7 Å	5 Å	4.48 Å	4.26 Å	4.03 Å	3.03	1.63 Å	2.89 Å
Rastrites F4	2828	25	13	24	92	15		19	
Rastrites F3	2894	37	12	39	83	15		7	
Rastrites F2	2942	24	10	26	87	17		14	
Rastrites F1	2981	22	12	29	97	13		13	
Dicellograp	3065	39	13	28	97	22		7	
Tøyen	3140	33	12	23	120	17		7	
Alum. L. Ordovician	3170	26	13	22	117	15		8	
Alum. L. Ordovician	3182	30	13	27	115	17		8	
Alum. L. Ordovician	3197	24	17	27	102	15		11	25
Alum. Furongian	3212	11	20	27	83	13		17	29
Alum. Furongian	3227	17	19	20	65	8	41	21	29
Alum. Furongian	3242	13	14	17	43	8	119	20	71
Alum. Furongian	3251	11	14	22	72	8		29	52
Alum. Furongian	3257	18	21	22	65	7		22	45
Alum. Furongian	3272	13	20	24	80	11		24	55
Alum. Middle Cambrian	3284	11	22	26	73	11		29	40
Alum. Middle Cambrian	3290	18	27	28	79	11		28	
Alum. Middle Cambrian	3305	26	18	24	65	12		29	41
Alum. Middle Cambrian	3317	31	18	23	57	9		20	26
Alum. Middle Cambrian	3329	34	20	21	89	11	60	9	

Table 5. Comparison between XRD results between GEUS (August 2012 data), Museum (Geological Museum December 2011) and RGM (TOTAL E&P, May 2012).

	GEUS	***GEUSCorr***	***RGM***	***Museum***	***GEUS***	***GEUSCorr***	***RGM***	***Museum***	***GEUS***	***RGM***	***Museum***	***GEUS***	***GEUSCorr***	***RGM***	***Museum***
Depth	Clay Minerals				Quartz+Fdps				Carbonates			Brittleness			
2828	57	50	48.8	52.7	33	40	39.5	40.1	4.3	4.4	2.0	0.40	0.47	0.47	0.44
2894	58	51	52.1	53.6	34	41	40.7	42.4	7	3.9	2.7	0.41	0.48	0.46	0.46
2942	51	44	46.5	52.0	38	45	41.7	38.2	5.7	4.6	5.6	0.46	0.53	0.50	0.46
2981	58	51	45.9	50.6	32	39	42.4	39.4	5.6	4.2	5.9	0.40	0.47	0.50	0.47
3065	55	48	50.6	52.6	37	44	40.3	41.9	4.5	2.1	3.2	0.43	0.50	0.46	0.46
3140	50	43	42.1	42.5	41	48	47.5	51.0	3.4	2.3	2.4	0.47	0.54	0.54	0.56
3170	46	39	34.4	39.4	44	51	52.6	53.8	4.3	4.4	2.2	0.51	0.58	0.62	0.59
3182	50	43	37.8	47.0	41	48	47.4	46.1	4	2.4	2.3	0.47	0.55	0.57	0.51
3197	51	44	44.9	48.5	36	43	38.6	38.6	5.3	5.2	5.7	0.45	0.52	0.49	0.48
3212	47	40	39.6	44.6	32	39	35.1	35.2	6.5	7.5	8.0	0.45	0.53	0.52	0.49
3227	46	39	33.6	38.6	25	32	33.6	30.1	12.8	15	15.8	0.45	0.53	0.59	0.54
3242	41	34	24.7	25.7	17	24	26.4	24.7	29.4	34	35.6	0.53	0.61	0.71	0.70
3251	44	37	33.5	39.6	27	34	30.2	30.4	12.9	18	14.6	0.47	0.56	0.59	0.53

Table 5. (continued).

	GEUS	***GEUSCorr***	***RGM***	***Museum***	***GEUS***	***GEUSCorr***	***RGM***	***Museum***	***GEUS***	***RGM***	***Museum***	***GEUS***	***GEUSCorr***	***RGM***	***Museum***
Depth	Clay Minerals				Quartz+Fdps				Carbonates			Brittleness			
3257	55	48	36.5	42.4	20	27	32.3	30.8	7.1	11	10.8	0.33	0.42	0.54	0.50
3272	44	37	39	41.7	32	39	32.9	29.5	9.1	13	15.2	0.48	0.56	0.54	0.52
3284	45	38	42.6	43.2	31	38	30.2	30.0	8.6	11	13.4	0.47	0.55	0.49	0.50
3290	52	45	45.3	46.1	30	37	31.0	32.2	4.1	7.5	7.3	0.40	0.48	0.46	0.46
3305	52	46	44	46.7	30	37	34.0	35.4	5.5	6.5	7.9	0.40	0.48	0.48	0.48
3317	55	48	46.7	47.0	29	35	34.0	36.1	5.9	5.4	7.3	0.39	0.46	0.46	0.48
3329	55	48	46.8	47.7	27	33	31.8	33.8	11.8	9.6	13.1	0.41	0.48	0.47	0.50
Avg	**48.7**	**41.9**	**39.2**	**42.7**	**30.0**	**36.8**	**35.0**	**34.8**	**9.1**	**10.7**	**11.4**	**0.44**	**0.52**	**0.52**	**0.51**

Table 6. Quantitative analysis table of samples from the Slagelse-1 well. Wt% of minerals rounded to 1%. Analysis preformed at the Geological Museum, November 2012.

Base (m)	**detrital silicates**				**clays**				**carbonates**					**sulphates**		
	Q	Alb	Micro	muscovite*	illite**	illite-smectite **	kaolinite	chlorite***	calcite	dolomite	ankerite	siderite	pyrite	gypsum	jarosite	magnesio-copiapite
2770.8	71	3	<1	2	10	2	1	9	-	-	2	-	-	-	-	-
2772.0	26	4	2	3	41	9	2	11	-	-	-	-	1	-	-	-
2773.5	23	3	2	4	38	9	3	13	-	-	-	-	2	2	-	-
2775.8	44	5	1	4	23	5	2	13	-	-	1	2	-	-	-	-
2776.4	31	4	2	3	32	9	3	12	-	-	-	-	1	2	-	-
2813.3	37	3	3	3	30	8	2	13	-	-	-	-	1	1	-	-
2814.5	28	4	2	4	35	9	3	15	-	-	-	-	1	1	-	-
2856.1	26	3	2	4	38	9	3	15	-	-	-	-	-	-	-	-
2905.3	34	2	1	4	32	8	3	14	-	-	2	-	-	-	-	-
2933.7	31	3	5	4	42	6	-	-	-	-	-	-	1	2	7	-
2933.8	27	3	4	3	44	6	-	-	-	-	-	-	2	2	6	2
2940	29	4	2	4	34	7	1	10	4	-	-	-	2	3	-	-
2952	27	3	2	3	29	7	2	10	2	11	-	-	2	2	-	-

* Estimated amount of muscovite with crystallite size 1µ and over.

** Without clay mineral separation and specific analysis it is difficult to characterize the clay completely. However, there is together with illite a clay which looks like illite-smectite. Due to poor crystallinity, the quantities cannot be assumed to be very accurate.

*** Chlorite is ferrous and falls in the field of chamosite-ripidolite.

Samples from the Slagelse-1 well

In order to correct the Quartz+ Feldspar content in the Slagelse-1 well 13 samples were analysed at the Geological Museum for its quantitative mineralogical composition (Table 6). The sum of quartz and feldspar measured at GEUS exhibit a statistical significant correlation to the sum of the quartz and feldspar content measured at the Geological Museums XRD laboratory (Figure 20). Based on this correlation the mineralogical composition of the Slagelse-1 samples have been corrected and the brittleness index has been calculated (Appendix B).

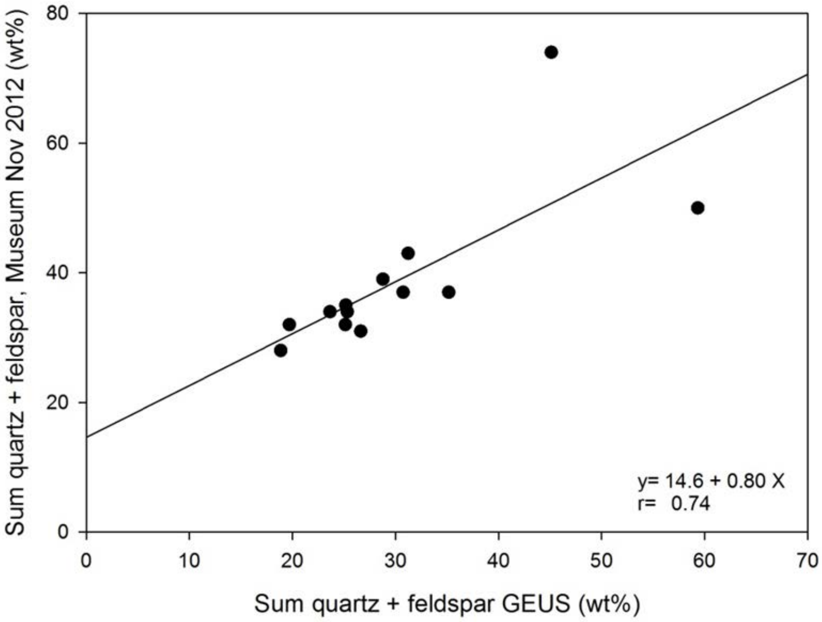

Figure 20. Comparison between the quartz + feldspar content in Slagelse-1 measured by GEUS and the quartz + feldspar content measured by the Geological Museum (Table 6). The two parameters are strongly correlated. Based on this correlation analysis the quartz + feldspar content in Slagelse-1 samples have been corrected. The corrected data are presented in Appendix B.

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7. Data included on CD

Attached to this report is a CD that contains the following documentation:

1. In folder *Table* are Excel versions of the tables presented in the report
2. In folder *Appendix* is an Excel version of Appendix A and B.
3. A pdf of this report: Interpretation of analytical results from the Terne-1 and Slagelse-1 wells.pdf

Appendix A Mineralogical composition of Terne-1 samples

Updated mineralogical composition of samples from the Terne-1 well. Abbreviations: Pyr: pyrite, Carb: carbonate, Q: quartz, K: kaolinite, Plag: plagioclase, $Clay_{tot}$: (K+ Clay + Mica), Corr. Correction according to Part 4 (Chapter 5) in this report. Britt: Brittleness expressed as $(Q+Carb+Plag)/(Q+Carb+Plag+Clay_{tot})$. The column 'XRD new' indicates samples in Schovsbo (2012) that are part of Schovsbo (2011b).

Unit	XRD new	depth	TOC	Pyr	Carb	Q	K	Mica	Clay	Plag	Q + Plag	Clay tot	Britt.
		m	%	%	%	%	%	%	%	%	corr.	corr.	
Rastrites F4	1	2813	1.2	3.8	3.4	27	20	13	24	8	42	49	0.45
Rastrites F4	1	2825	1.5	5.9	4.3	36	15	7	18	12	55	34	0.59
Rastrites F4		2828	1.5	4.1	4.3	19	23	12	22	14	40	50	0.44
Rastrites F4	1	2843	0.7	3.8	4.7	26	23	10	21	12	44	46	0.48
Rastrites F3	1	2867	0.0	0.6	5.8	42	21	6	12	12	61	33	0.63
Rastrites F3	1	2876	0.2	1.4	6.7	24	32	11	20	6	36	56	0.41
Rastrites F3		2894	0.0	1.3	7.0	24	24	8	26	10	41	51	0.45
Rastrites F3	1	2903	0.1	1.2	7.6	20	31	10	18	12	38	53	0.44
Rastrites F3	1	2924	0.3	2.1	5.8	30	22	8	17	14	51	41	0.55
Rastrites F2		2942	1.3	3.6	5.7	24	20	9	22	14	45	44	0.50
Rastrites F2	1	2954	0.9	2.7	5.1	21	27	9	21	13	40	51	0.44
Rastrites F1	1	2957	1.2	3.6	6.6	35	15	8	18	13	54	34	0.60
Rastrites F1	1	2960	1.3	2.6	5.6	20	21	11	24	14	41	49	0.45
Rastrites F1		2981	1.5	3.2	5.6	20	20	11	26	12	39	51	0.44
Lindegård	1	3002	0.4	2.8	5.5	19	28	11	21	12	38	54	0.42
Dicellograptus	1	3029	1.5	2.0	4.9	21	29	10	21	12	39	52	0.43
Dicellograptus	1	3053	1.1	2.6	4.8	22	25	10	18	16	44	47	0.48
Dicellograptus		3065	0.8	2.0	4.5	22	27	9	19	15	44	48	0.47
Dicellograptus	1	3083	0.8	1.8	5.3	27	22	9	22	13	46	46	0.50
Almelund	1	3122	0.8	1.5	5.2	23	28	7	19	14	44	48	0.47
Tøyen		3140	1.5	4.4	3.4	28	24	9	17	12	48	43	0.51

Appendix A (Continued)

Unit	XRD new	depth	TOC	Pyr	Carb	Q	K	Mica	Clay	Plag	Q + Plag	Clay tot	Britt.
		m	%	%	%	%	%	%	%	%	corr.	corr.	
Tøyen	1	3143	0.6	2.2	14.3	25	24	9	16	9	41	42	0.53
Tøyen	1	3155	0.9	1.8	8.9	22	26	11	17	11	40	48	0.47
Tøyen	1	3167				21							
Alum, L. Ordovician		3170	3.0	2.2	4.3	33	20	10	17	11	51	39	0.55
Alum, L. Ordovician	1	3179				22							
Alum, L. Ordovician		3182	2.7	2.4	4.0	29	21	9	19	12	48	43	0.51
Alum, L. Ordovician	1	3188	5.0	2.3	4.0	21	18	13	23	14	42	47	0.46
Alum, L. Ordovician		3197	4.8	3.2	5.3	25	18	13	20	11	43	44	0.49
Alum, L. Ordovician	1	3200	5.4	3.5	6.2	24	20	13	18	9	40	45	0.47
Alum, L. Ordovician	1	3203	6.3	4.7	3.9	26	15	13	20	10	44	42	0.50
Alum, Furongian	1	3209	7.2	6.5	2.8	24	17	14	20	8	38	45	0.44
Alum, Furongian		3212	6.6	8.6	6.5	21	9	16	22	10	38	40	0.49
Alum, Furongian	1	3215	8.2	8.0	2.9	26	0	17	27	11	44	37	0.52
Alum, Furongian	1	3218	10.7	5.0	17.1	40	6	6	9	6	53	14	0.77
Alum, Furongian	1	3221	13.7	5.7	4.7	25	0	18	22	12	43	33	0.55
Alum, Furongian	1	3224	12.2	6.5	2.7	25	0	18	25	11	43	36	0.52
Alum, Furongian		3227	9.9	6.8	12.8	18	14	16	16	7	32	39	0.49
Alum, Furongian	1	3230	9.2	6.8	18.6	19	13	13	15	5	30	35	0.54
Alum, Furongian	1	3233	9.3	7.0	17.9	36	10	7	8	4	47	19	0.72
Alum, Furongian	1	3236	10.2	6.1	13.5	22	15	11	14	8	36	34	0.55
Alum, Furongian	1	3239	10.3	10.3	9.5	18	14	13	18	8	32	38	0.48
Alum, Furongian		3242	7.5	5.4	29.4	10	12	13	16	7	24	34	0.57
Alum, Furongian	1	3245	7.6	8.0	15.4	30	10	10	13	7	44	25	0.65
Alum, Furongian	1	3248	7.9	8.5	8.0	19	0	25	32	0	25	50	0.37
Alum, Furongian		3251	7.6	8.8	12.9	19	10	13	21	7	34	37	0.51
Alum, Furongian	1	3254	6.5	3.9	15.8	19	10	16	19	10	35	39	0.53

Appendix A (Continued)

Unit	XRD new	depth	TOC	Pyr	Carb	Q	K	Mica	Clay	Plag	Q + Plag	Clay tot	Britt.
		m	%	%	%	%	%	%	%	%	corr.	corr.	
Alum, Furongian		3257	11.1	6.6	7.1	14	16	19	20	6	27	48	0.38
Alum, Furongian	1	3260	10.7	6.7	4.6	18	14	17	20	8	33	45	0.42
Alum, Furongian	1	3263	9.4	7.9	5.7	37	8	13	14	5	49	28	0.61
Alum, Furongian	1	3269	7.1	7.5	8.3	20	11	19	28	0	27	50	0.38
Alum, Furongian		3272	7.7	7.0	9.1	24	10	15	19	8	39	37	0.52
Alum, Middle Cambrian	1	3275	6.9	6.9	10.7	21	8	17	22	8	35	40	0.49
Alum, Middle Cambrian	1	3278	7.2	8.1	4.0	23	12	17	20	9	38	42	0.46
Alum, Middle Cambrian		3284	6.8	8.0	8.6	23	8	17	20	8	38	38	0.51
Alum, Middle Cambrian	1	3287	5.5	8.1	8.9	19	13	17	22	7	33	45	0.44
Alum, Middle Cambrian		3290	6.6	7.7	4.1	22	13	19	20	8	37	45	0.44
Alum, Middle Cambrian	1	3296	4.2	7.8	10.2	17	19	13	21	8	32	46	0.44
Alum, Middle Cambrian	1	3299				16							
Alum, Middle Cambrian	1	3302	6.6	5.3	4.4	22	15	16	23	8	37	47	0.44
Alum, Middle Cambrian		3305	5.6	6.7	5.5	20	20	14	19	9	37	46	0.44
Alum, Middle Cambrian	1	3314	5.5	4.2	5.4	21	21	14	20	8	36	49	0.43
Alum, Middle Cambrian		3317	5.7	4.9	5.9	22	24	14	18	7	35	48	0.43
Alum, Middle Cambrian	1	3320	5.5	4.5	17.3	18	23	13	14	5	30	43	0.49

Appendix A (Continued)

Unit	XRD new	depth	TOC	Pyr	Carb	Q	K	Mica	Clay	Plag	Q + Plag	Clay tot	Britt.
Alum, Middle Cambrian	1	3323	6.3	5.1	8.1	19	22	17	17	7	32	48	0.42
Alum, Middle Cambrian		3329	2.7	3.7	11.8	18	25	15	15	8	33	49	0.45
Alum, Middle Cambrian	1	3332	1.8	1.4	15.6	21	24	10	16	10	38	44	0.51
Alum, Middle Cambrian	1	3338	2.8	3.5	9.5	29	17	10	17	12	47	37	0.57

Appendix B Mineralogical composition of Slagelse-1 samples

Material	Unit	depth	TOC	Pyr	Carb	Q	K	Mica	Clay	Q+Feldsp	Total Clay	Britt.
		m	%	%	%	%	%	%	%	corr.	corr.	
Core	Silurian	2770.8	0.6	0.10	1.6	45	37	7	7	51	47	0.51
Core	Silurian	2771.2	0.0	0.22	4.2	19	35	19	19	30	65	0.32
Core	Silurian	2772.0	0.1	0.60	1.1	20	32	26	26	30	68	0.27
Core	Silurian	2773	0.0	2.44	2.6	21	37	18	18	32	63	0.32
Core	Silurian	2773.5	0.1	0.23	0.7	19	40	20	20	30	69	0.28
Core	Silurian	2774	0.0	0.65	3.6	31	38	13	13	39	57	0.40
Core	Silurian	2775.0	0.1	0.35	1.2	23	37	20	20	33	66	0.31
Core	Silurian	2775.8	0.1	1.06	3.7	59	22	7	7	62	33	0.64
Core	Silurian	2776.4	0.1	1.82	0.4	31	31	20	20	39	58	0.36
Picked Cuttings	Silurian	2780	0.0	0.43	3.3	28	37	14	14	37	59	0.39
Core	Silurian	2813.3	0.0	0.89	0.4	31	39	14	14	40	59	0.38
Core	Silurian	2814.5	0.1	0.65	0.4	24	41	17	17	34	65	0.31
Picked Cuttings	Silurian	2823	0.1	0.72	2.7	22	36	18	18	33	64	0.33
Picked Cuttings	Silurian	2832	0.2	0.38	3.3	29	35	15	15	38	58	0.38
Picked Cuttings	Silurian	2835	0.0	0.41	3.3	27	37	13	13	36	60	0.38
Picked Cuttings	Silurian	2841	0.1	0.53	4.8	28	33	18	18	37	57	0.38
Picked Cuttings	Silurian	2847	0.0	0.39	4.3	23	37	17	17	33	62	0.34
Picked Cuttings	Silurian	2853	0.3	0.46	3.3	32	36	13	13	40	56	0.41
Core	Silurian	2855.8	0.2	0.05	0.7	52	33	7	7	56	43	0.55
Core	Silurian	2856.1	0.2	0.08	0.8	27	41	14	14	36	63	0.35

Appendix B (continued)

Material	Unit	depth	TOC	Pyr	Carb	Q	K	Mica	Clay	Q+Feldsp	Total Clay	Britt.
		m	%	%	%	%	%	%	%	corr.	corr.	
Picked Cuttings	Silurian	2862	0.0	0.36	3.3	26	40	12	12	36	61	0.38
Picked Cuttings	Silurian	2871	0.0	0.57	4.9	23	37	17	17	33	62	0.35
Picked Cuttings	Silurian	2877	0.1	0.41	2.7	24	37	16	16	34	63	0.34
Picked Cuttings	Silurian	2883	0.0	0.54	3.2	24	39	14	14	34	62	0.36
Picked Cuttings	Silurian	2892	0.1	1.02	2.7	23	38	17	17	33	63	0.33
Picked Cuttings	Silurian	2895	0.0	0.51	5.2	24	33	13	13	33	61	0.40
Core	Ordovician	2905.3	0.1	0.09	1.7	35	38	13	13	43	55	0.41
Picked Cuttings	Ordovician	2912	0.0	0.34	3.7	34	35	13	13	42	54	0.43
Picked Cuttings	Ordovician	2915	0.1	0.61	2.5	26	41	14	14	35	62	0.35
Picked Cuttings	Ordovician	2918	0.1	1.83	2.9	24	37	17	17	33	62	0.34
Picked Cuttings	Ordovician/Alum Shale	2921	0.1	0.40	2.2	23	42	14	14	33	64	0.33
Picked cuttings	Alum Shale (100% Caving)	2924	0.1	0.52	2.4	28	37	16	16	37	60	0.36
Picked Cuttings	Alum Shale (100% Caving)	2927	0.1	0.79	3.1	29	36	15	15	38	58	0.38
Picked Cuttings	Alum Shale (100% Caving)	2930	0.2	0.66	3.8	26	37	14	14	36	60	0.37
Core	Alum Shale	2932.6	6.9	####	2.0	22	0	31	31	32	49	0.35
Core	Alum Shale	2933.0	8.6	5.57	0.1	29	0	30	30	38	48	0.39
Core	Alum Shale	2933.7	8.5	6.14	0.0	29	0	32	32	38	48	0.37

Appendix B (continued)

Material	Unit	depth	TOC	Pyr	Carb	Q	K	Mica	Clay	Q+Feldsp	Total Clay	Britt.
		m	%	%	%	%	%	%	%	corr.	corr.	
Core	Alum Shale	2933.8	8.3	6.96	0.0	25	0	33	33	35	50	0.35
Picked Cuttings	Alum Shale (Caving significant)	2937	2.3	2.42	6.3	26	30	14	14	35	54	0.42
Picked Cuttings	Alum Shale (Caving significant)	2940	3.2	2.50	5.7	25	31	12	12	35	54	0.43
Picked Cuttings	Alum Shale (Caving significant)	2943	2.6	2.21	4.8	25	32	14	14	34	56	0.39
Picked Cuttings	Alum Shale (Caving significant)	2946	2.1	2.10	2.2	26	32	16	16	36	58	0.37
Picked Cuttings	Alum Shale (Caving significant)	2949	2.7	2.77	3.7	28	28	15	15	37	54	0.41
Picked Cuttings	Alum Shale (Caving significant)	2952	2.0	2.00	9.3	25	33	12	12	35	52	0.44
Picked Cuttings	Alum Shale (Caving significant)	2955	0.1	0.68	2.6	25	39	13	13	35	62	0.36