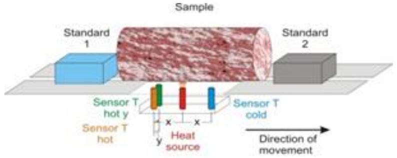
Page, Line	Comments from Referees	Author's response	Author's changes in the manuscript
Referee 1 – C2 line 1	*“However, besides the thermo- and petrophysical properties, the heat flow of the basin has to be taken into account to assess the economic feasibility. In the conclusions I would like to see this point addressed – alternatively the authors might add an outlook where they list the next steps to localize the most promising area with regard to depth and temperature including the available information from published data. Eventually, it is the economically recoverable heat (ERH) which increases the feasibility and this should be clearly stated at the end of the paper.”*	We agree with Referee 1 that heat flow is an important parameter and should be taken into account during the assessment of the economic feasibility of a geothermal reservoir. This study was intended to create an initial data set of Upper Devonian carbonate rock properties relevant to geothermal modelling. Statements about economic feasibility were not planned for this early stage of the project, however, a short section will be added to the chapter “discussion and conclusions” summarizing the most important parameters necessary to assess the economic feasibility of this reservoir. Outlook: To complement the data set presented in this study, measurement of further parameters (e. g. thermal diffusivity, specific heat capacity and ultrasonic wave velocity) on well core samples has been planned. Well data provided in the AccuMap or GeoScout databases will be evaluated, interpreted and probably mapped to identify the most promising areas for geothermal utilization in the reservoir. Due to the high amount of well data, this will be only possible on a regional scale. The construction of a regional geological 3D model, using already existing data from previous studies (Majorowicz et al., 2012; Nieuwenhuis et al, 2015), is planned for the most promising areas.	We added a new section to line 5 on page 15: " The classifications by Sass and Götz (2012) and Bär et al. (2011) were applied on the rock properties for a first assessment. The application of the thermofacies concept (Sass and Götz, 2012) is useful in an early exploration stage or in cases where detailed reservoir information is not available but it does not replace further exploration. Likewise, the threshold values applied in Bär et al. (2011) were defined for a low enthalpy region in Germany and are used as indicators, which will likely need to be redefined for the Upper Devonian aquifer systems with increasing experience of geothermal exploitation in this specific reservoir. Rock property measurements provide matrix properties only (mesoscale). Furthermore, they need to be corrected for reservoir conditions and transferred to reservoir scale (up- and downscaling). For a more reliable geothermal assessment, further reservoir parameters (macroscale) like reservoir temperature, flow rates, heat flow, potentiometric surfaces, TDS and H_2S content etc. are needed. Therefore it is necessary to evaluate well data provided in the AccuMap or GeoScout database. These databases comprise an enormous amount of well data from various companies from the last seven decades. However, there is no information given about the quality of the data. In particular, temperature data were identified as inaccurate (Weides and Majorowicz, 2014). Furthermore, heat flow values have been corrected for paleoclimatic surface temperature forcing (Majorowicz et al., 2012). As the Leduc Formation is relatively homogenous within the Alberta Basin, reservoir temperature is one of the crucial parameters. An important point will be to identify ‘hot spots’ at an economical depth. Likewise, flow rates are very variable at a local scale (Lam and Jones, 1985) and need to be analyzed to evaluate the economic geothermal potential. Furthermore, the aquifer systems need to be operated as transitional systems which need stimulation. This point needs to be considered during cost calculation. Most natural geothermal systems need stimulation for economic and technical reasons (Sass and Götz, 2012). According to the AccuMap database, reservoir stimulation was also a common process for increasing the productivity during oil and gas production. Previous studies (Hofmann et al., 2014) indicate that stimulation treatments can increase the economic feasibility for geothermal utilization in the WCSB for at least some reservoir formations.

			A limiting factor for geothermal utilization in the study area is the complex hydrogeology. Both formations (Leduc and Nisku) contain highly concentrated water with average TDS values of approximately 200 g l^{-1} (Rostron et al., 1997; Michael et al., 2003). Within the SCCC, salinity increases with increasing distance from the Rocky Mountains (‘squeegee flow’, Buschkuehle and Machel, 2002; Machel and Buschkuehle, 2008). This parameter can be also very variable at a local scale. In the Hinton-Edson area, salinity ranges from less than 50 g l^{-1} up to 180 g l^{-1} (Lam and Jones, 1985). Likewise, the Nisku Reef Trend is well known for its (over pressured) sour gas pools (Bachu et al., 2008). Problems like scaling and corrosion during operation can lead to higher production costs or in the worst case scenario to the abandonment of the well. These problems are not solved in the geothermal industry yet but should be addressed in the current discussion about a geothermal pilot project in the WCSB. For this reasons a close cooperation with the oil industry is important. Using the experience in operating this reservoir, the existing equipment and infrastructure likely reduces exploration risks and costs for a geothermal project which could provide new business strategies. For the next phase of the project, further parameters (e.g. heat capacity, thermal diffusivity and ultrasonic wave velocity) will be measured on well core samples to complement the data set provided in this study. It is also considerable to extent the study area or include further formations to cover areas with higher heat flow or temperatures. Well data provided in the AccuMap or GeoScout databases will be evaluated, interpreted and probably mapped to identify the most promising areas for geothermal utilization in the reservoir. Due to the high amount of well data, this will be only possible on a regional scale. The construction of a regional geological 3D model, including already existing data from previous studies (Majorowicz et al., 2012; Nieuwehuis et al., 2015), is planned for the most promising areas.
Referee 1 – C2 line 7	*“The dataset clearly shows that the aquifer systems under discussion have to be operated as transitional system and thus need stimulation. Again, a point to be considered for economic operation.”*	Agreed**.** This point needs to be considered during cost calculation and for economic operation. We will add this point in chapter 6 “Discussion and conclusions”.	See changes above.

Referee 1 – C2 line 12	”*Please, check the reference list for consistency (also fonts).”*	Thank you very much for the detailed proofreading. The reference list was checked and corrected accordingly.	The reference list was checked and corrected.
Referee 1 – C2 line 12	”*Can you please add the coordinates of the outcrop and well locations in Table 1.”*	A list of coordinates of the outcrops and well locations was added to Appendix B.	A list of coordinates of the outcrops and well locations was added to Appendix B. "The exact coordinates of the wells and outcrops are added to Appendix B." was added to line 19 on page 6 in chapter Material and Methods.
Referee 2 – C2 line 8	“*Some information on the samples prep. and orientation should be given (saturated or dry; whether or not the thermal conductivities are known to be the vertical (perpendicular thermal conductivity)?”*	Thermal conductivity was measured according to the method of Popov et al. (1999) on dry samples as shown in Fig. 1. Therefore, thermal conductivity of the core samples represents the “horizontal“ thermal conductivity. We will add Fig. 1 to the relevant chapter, Material and Methods, in the manuscript. Sample preparation: To minimize the transmission of optical heater radiation into reference standards and rock samples resulting from optical transparent surfaces (Popov et al., 2016), black paint was applied along a scan line on the sample surfaces as well as on the standards. Measurement of the plane surfaces of the core samples in order to estimate the thermal anisotropy was not allowed.	Fig. 1 was added to chapter 'Material and Methods' (=new Fig. 5). The section in line 10 on page 7 was changed to:" For determination of thermal conductivity and thermal diffusivity, a thermal conductivity scanner was used (Popov et al., 10 1999), allowing non-destructive as well as contactless measurements by using infrared sensors. To minimize the transmission of optical heater radiation to reference standards and rock samples resulting from optical transparent surfaces (Popov et al., 2016), black paint was applied along a scan line on the sample surfaces as well as on the standards. Both parameters were measured three to four times on each plug (see Fig. 5). The measurement accuracy is 3 % (Lippman and Rauen, 2009)." We also changed the section in line 27 on the same page to: "The study included further core analyses and measurements of thermal conductivity and permeability on core samples 5 cm to 70 cm long. Thermal conductivity was determined on the mantle surface at dry conditions in the same procedure described for the outcrop analogue samples (as shown in Fig. 5)." 

Referee 2 – C2 line 11	*"As to compare above thermal conductivity , porosity new measurements with previously published results, I would recommend reference to Beach et al., Geothermics, Vol. 16, No. I, pp. 1-16, 1987 with averages based on hundreds of thermal conductivity and porosity for carbonates and other rock types from mainly Hinton- Edson area."*	Ok. The data set included in Beach et al. 1987 comprises thermal conductivity values measured on several hundred "water-saturated porous samples" (Beach et al. 1987, p.3). These thermal conductivity values were measured with a divided-bar apparatus and are stated as the vertical or perpendicular thermal conductivity. This data set was not mentioned in the manuscript because it does not contain any information about the origin (well location and depth) of the samples, a reference to the different formations in the basin, nor a detailed rock description. The data set provided in Beach et al. (1987) gives a good overview of thermal conductivity of 13 rock types of the Mesozoic, Cenzcoic and Paleozoic sediments in the Hinton-Edson area. The thermal conductivity values of each rock type represent mean values calculated from different depth levels with varying thickness. The data set gives no information about specific formations and how the properties change within a formation. Therefore, this data set is more useful for large scale observations. In Jones et al. (1984) thermal conductivity in the Hinton-Edson area (most likely the same data set – 936 water saturated samples from 48 wells measured with a divided bar apparatus) is given for four geological formation groups. Jones et al. (1984) states that although a lot of samples were analysed, that some came from very small depth intervals and most of the cores are from very porous and permeable formations. Therefore, this data set is not representative for all relevant parts in the reservoir. The thermal conductivity values presented in this manuscript were measured on dry samples, not on saturated samples. It is to emphasize that thermal conductivity values measured on dry samples as well as thermal conductivity values	We added the following section to line 5 on page 3 (Introduction): "Within the study area, thermal properties measured on core samples exist only for the Hinton-Edson area. Beach et al. (1987) gives a good overview of thermal conductivity of 13 different rock types of the Mesozoic, Cenozoic and Paleozoic sediments in this area of the Alberta Basin but not for specific formations or how the properties might change within a reservoir. We changed line 22 on page 11 to: "Thermal conductivity of the reservoir samples varies between 2.4 W m-1 K-1 (bank-edge reef, well 2-19, Nisku) and 5.5 W m-1 K-1 (reef facies, well 7-33, Nisku). Table 3 provides an overview of average thermal conductivities (arithmetic mean and standard deviation) for each analyzed member and formation. There is no difference between the Leduc Formation of the RMRT and the SCCC. Within the Nisku Formation, the argillaceous limestones of the Lobstick Member show the lowest thermal conductivity, while thermal conductivity of the Zeta Lake Member is within the range of the Leduc Formation." We added "Likewise, the" to 27 on the same page. We added "independent of depth" to line 32 on page 12. We added the following section to line 24 on page 14:"The measured thermal conductivity values presented in this work are within the range of data sets included in previous studies. Some examples are given in Table 4. Further data sets are also listed in Grasby et al. (2012). Measurements of thermal conductivity of whole drill cores have shown that thermal conductivity is independent of depth in the study area. Additionally, thermal conductivity shows no correlation with porosity. Similar findings were made in Jones et al. (1984). With the exception of the Hinton-Edson area, no 'hard' data exists for thermal conductivity in the study area. Beach et al. (1987) and Jones et al. (1984) provide average thermal conductivity values for different lithologies measured on several-hundred water-saturated core samples with a divided bar apparatus mainly taken from wells in the Hinton-Edson area. The data set provided in Beach et al. (1987) represents mean values for different rock types of Mesozoic, Cenzoic and Paleozoic sediments and is more useful for large scale observations. Thermal conductivity given for dolomites is about 1 W m^{-1} K^{-1} lower than that presented in this work (note: not recalculated for water saturated conditions). In Jones et al. (1984), thermal conductivity is given for four geological formation groups. Thermal conductivity given for dolomitic limestones fits very well

		measured on water-saturated samples do not reflect the real conditions in the reservoir and need to be corrected before modelling.	to the results for partially dolomitized limestones shown in Table 3. However, the core samples which were used for the thermal conductivity measurements in the Hinton-Edson area are mainly taken from very porous and permeable zones and, in some cases, from very small depth intervals (Jones et al., 1984). Therefore, they do not represent all relevant parts of the reservoir. The other thermal conductivity values presented in Table 4 are included to demonstrate the variability of this parameter for different facies and/or reservoirs. According to Popov et al. (2016), thermal rock properties are critical parameters for thermo-hydrodynamic models and for predicting the lifetime performance of geothermal systems. Therefore an accurate determination of thermal properties of each relevant formation is necessary.”

Referee 2 – C2 line 25	"*b) There are many statements related to an assessment of the geothermal energy potential of the carbonate aquifers and reefs in the study area. While porosity, permeanbility , temperature conditions, thermal conductivity ,diffusivity, are important to such evaluation it is not possible to recommend geothermal energy potential without take on other parameters like the hydraulic head, piezometric surfaces, mineralization of aquifer fluids and most important estimate of potential flow rates at well head. In that sense cited by the authors paper by Jones and Lam Can. J. Earth Sci. 1985 went farther and gives such information (see their figs.10-12 and their Appendix figures). I recommend that their results be described, evaluated and briefly discussed in the scope of geothermal energy eval..*"	Ok. As mentioned before, at this early stage of the project, we focused on examining the Upper Devonian carbonates for geothermal purposes and to measure rock properties which are relevant to geothermal exploration and modelling. The classifications by Sass and Götz (2012) and Bär et al. (2011) were used for the initial evaluation of the measured rock properties. We do not claim that they replace further investigation. As mentioned in the manuscript (p. 13, line 22) "rock property measurements produce conservative results and represent matrix properties only" and additional parameters need to be integrated in a geological model for a reliable reservoir prediction. Therefore, our statements are not contradictory to the comments by Referee 2. Due to the high number of well data (several thousand wells) that need to be evaluated for a reliable assessment of the Upper Devonian aquifer systems in the study area, the parameters required by Referee 2 are not included in this manuscript. This will be considered in the next phase of the project. To make this clear, we will add a short section about the most relevant parameters and give an outlook of the next steps according to the hints of Referee 2.	See changes above: R1 C2 line 1.
Referee 2 – C3 line 8	*"It is not entirely justified to make statements in the paper like this one: …"*	Agreed.	This section in line 11 on page 15 was deleted according to the hints of R2. Likewise the sentence in the Abstract on page 2.

Referee 4 – C3 line 20	”*At their paper The Autors do not address the issue of potential brine production as they do not address parameters needed to estimate it in their paper*.”	Thank you very much for this advice. As mentioned above, this manuscript focuses on rock properties. It was not intended for statements about economic and technical risks during production. Regarding the recent efforts in the Hinton-Edson area to create an initial geothermal project, it is important to consider the complex hydrogeology in these aquifer systems. Both formations (Leduc and Nisku) contain highly concentrated waters with average TDS values of approximately 200 g/l (Rostron et al., 1997; Michael et al., 2003). Likewise, the Nisku Formation is well known for its sour gas pools (Bachu et al., 2008). Problems like scaling and corrosion during operation can lead to higher production costs or, in the worst case scenario, to the abandonment of the well. These problems have not been solved in the geothermal industry yet. The hydrochemistry of the aquifer systems in the study area has been the subject of several previous studies (e.g. Lam and Jones, 1985; Rostron et al., 1997; Buschkuehle and Machel, 2002; Michael et al., 2003, Machel and Buschkuehle, 2008) because it was also the main interest of the oil industry. As Lam and Jones (1985) have showed, these parameters can be very variable on a local scale. In the Hinton-Edson area the salinity ranges from less than 50 g/l up to 180 g/l.	See changes above: R1 C2 line 1.

Referee 4 – C1 line 11	*“a missing topic in this interesting chapter is the "upscaling-donwscaling" of the properties (reservoir and geothermal)”*	We agree that upscaling and downscaling of the rock properties is essential for reservoir modelling. As far as we did not model in this study, we did not elaborate this point in this manuscript. For the upscaling of the rock properties from plug to reservoir scale, further data should be included, which is beyond the scope of this study. So we agree to give information about “upscaling-downscaling” according to the hint of Referee 4: - upscaling in porous media: e.g. Renard et al. (1997), Farmer (2002) - stratigraphy based upscaling permeability and porosity in carbonate platforms: e. g. Leonide et al. (2012), Borgomano et al. (2013), Brigaud et al. (2014) - upscaling of thermal conductivities: Rühaak et al. (2015). Reservoir properties of carbonate rocks and their upscaling are related to architecture and facies. Nevertheless, our results show that (pervasive) dolomitization has affected the reservoir parameters of the Western Canadian Sedimentary Basin in an equitable degree.	To make it clear we did not upscale the properties here. See changes R4 p.13 line 7.
Referee 4 – C2 line 1	*“Another implicit assumption is that rock properties statistics are not dependent of sample size (no "support effect").”*	We do not claim that property statistics are independent from sample size. According to the hint of Referee 4 we will consider this point and add it to the section about upscaling and downscaling.	See changes R4 p.13 line 7.

Referee 4 – p. 3 line 21	*"what are precisely these "properties" and at what scale are they considered? Be more precise here"*	Homuth et al. (2015) analyzed density, porosity, permeability, thermal conductivity, thermal diffusivity and specific heat capacity on plugs from more than 350 samples taken from 19 outcrops in the Swabian and Franconian Alb as well as on core samples and cutting material from wells in the Molasse Basin in order to obtain a large enough data base for upscaling and correlation of the geothermal properties. The rock samples were classified with respect to the dominant reservoir facies types in order to identify facies dependant trends. To transfer the petrophysical properties to reservoir conditions, a Thermo-Triaxial-Cell was used to simulate pressure and temperature conditions of the reservoir. Furthermore, data from previous studies (bio- and lithostratigraphic model of the target formation) and well data were included.	We added the following sentence to page 3 line 21: "The samples were analyzed for thermal- and petrophysical properties like density, porosity, permeability, thermal conductivity, thermal diffusivity as well as specific heat capacity. Furthermore the samples were classified with respect to the dominant reservoir facies types in order to identify facies dependent trends." For more details about measurements methods the reader should read the paper about the Molasse Basin. This section is already very long and should just give a rough idea why we did this in the Alberta Basin.
Referee 4 – p.3 line 24	*„if you mean "physical-chemical rock properties" it needs to be demonstrated that outcrop and subsurface rocks are analogues (given different burial, structural, and diagenetic history, including telogenesis); if you mean facies, stratigraphic architecture/diemensions, sedimentrry bodies etc...the analogy is probably ok"*	The term "analogue" in this manuscript refers to "facies, stratigraphic architecture, and sedimentary bodies". Our study results are in agreement with your comment, as described later on in chapter "discussion and conclusions" (p 14, line 25ff).	How the term "analogue" is meant in this context is described on page 3 in line 14.

Referee 4 – p. 3 line 29	*"how do you measure thermophysical properties at all these scales?"*	The multi-scale method includes analysis on three different scales 1) macro scale (outcrop, well data) 2) meso scale (rock samples/plugs) and 3) micro scale (thin section, chemical analysis etc.). Macro-scale studies include well data (e.g. hydraulic tests, heat flow) as well as outcrop investigation (facies, structures). It is to emphasize, that not every parameter can be "measured" on every scale. In this manuscript we focused on the meso and micro scale (rock samples and thin sections).	No changes necessary.
Referee 4 – p. 3 line 30	*"it is not because you are doing multi-scale assessment that the properties or charactéristics are automatically upscales and downscaled! It depends also of the intrinsic heterogeneity of the system at all scales"*	We agree with Referee 4. To make it clear, we will add a short section about upscaling and downscaling in the manuscript.	See changes R4 p. 13 line 7.

Referee 4 – p.8 line 9	*“what are the key parameters for this classification? Are they universal or are they dependent of local conditions, basin, etc...”*	This classification especially considers economic and technological factors for geothermal utilization of the Federal state of Hesse in Germany. To assess the rock and reservoir properties in the 3D structural model of the Federal State of Hesse, a multiple criteria approach was used to incorporate their relevance for geothermal systems (Bär et al., 2011, Bär and Sass, 2014). Based on an extensive data base of rock properties and reservoir data, the threshold values (very low to very high) were defined to specify the geothermal potential. Since there exist no such data base for the Alberta Basin (and also no experience with geothermal power/heat generation), this classification was applied to the rock properties presented in this manuscript for a first evaluation.	This section in line 8 on page 8 was changed to give more information: "For an initial evaluation of the geothermal potential (listed in Table 2), the rock properties of the outcrop and core samples (Fig. 8 to 10) were classified into five levels of potential, as previously done in a 3D structural model of the German federal state of Hesse (Bär et al., 2011; Arndt et al., 2011; Bär and Sass, 2014). Within the 3D structural model, volumetric stratigraphic grids (SGrids) were created for each particular unit. After parameterizing the grids based on an extensive database of petro- and thermophysical rock properties for each unit combined with data from more than 4150 wells (e. g. results of pump tests and in-situ temperature measurements), a multi criteria approach was used to incorporate the relevance of the rock and reservoir properties for geothermal systems (Arndt et al, 2011). Threshold values ranging from 'very low' to 'very high' were defined for every parameter to specify the geothermal potential. These are based on experience in geothermal exploitation in Germany and particularly consider technical and economic factors. For example, the minimum temperature for district heating is defined as 60 °C and 100 °C defines the minimum temperature where electricity productionis technically possible. At temperatures above 120 °C (in combination with production rates above 50 m^3/h), electricity production becomes economically intresting. The classification of potential is explained in detail in Arndt et al. (2011). Reservoir properties are not considered here.
Referee 4 – p. 9 line 20	*“Petrography Outcrops” changed to “Outcrop petrography”*	Accepted.	Line 20 on page 9 was changed to: Outcrop Petrography

Referee 4 – p. 11 line 31	*"dry samples? It may change when samples are saturated with water?"*	Sentence will be changed to: "… The sample set shows no correlation between thermal conductivity and porosity." According to Popov et al. (2016) thermal conductivity of rocks depends on the mineral composition, interstitial porosity and fluids filling pores and fractures as well as mineral grain size and orientation, anisotropy of the rock matrix and the nature of grain contacts. Thermal conductivity of water is ~ 0.6 W m^{-1} K^{-1}, while thermal conductivity of air is approx. 0,025 W m^{-1} K^{-1}. Therefore, bulk thermal conductivity generally increases with increasing water content depending on the porosity of the rock sample. Likewise, bulk thermal conductivity of a rock sample generally decreases with increasing porosity. Our data set indicates no correlation between thermal conductivity and porosity. It is most likely, that in this case mineral composition, grain size/geometry and grain contacts have a stronger influence on thermal conductivity than the porosity of the samples (plug scale).	The sentence in line 31 on page 11 was changed to: "The sample set shows no correlation between thermal conductivity and porosity Fig. 7c)." .

Referee 4 – p. 12 line 2	*"that is in contradiction with the statement in the introduction."*	The "thermo facies concept" was explained in chapter 1 "Introduction" by the example of the Southern German Molasse Basin. This concept was successfully applied in the Southern German Molasse Basin to assess the geothermal potential of the Malm-Aquifer (Homuth et al., 2015). For this reason, we considered it appropriate to apply this methodology to the Upper Devonian carbonates in Alberta. Our results show the limits of this method. Although we could identify several similarities between the outcrops and the reservoir core samples, the outcrops are no valid proxies for the buried reservoirs in the Alberta Basin. This implies that, besides many similarities (rock types, thicknesses, depth and deformation, hydrogeological properties) the term 'analogue' needs to be specified.	See changes above R1 C2 line 1.
Referee 4 – p. 12 line 5	*" in outcrop conditions, not necessarlily in subsurface conditions"*	Yes that is correct, but here we meant it in a different context. According to several transfer models (Allen and Allen, 1990; Pape et al., 1999, etc.) porosity and permeability generally decrease with increasing depth. Permeability of the outcrop samples is already significantly lower than permeability of the well core samples, even though the results are not corrected for reservoir conditions yet. We will specify this.	See changes below: C4 p13 line 7.

Referee 4 – p.12 line 14	*"what type of pore space? intergranular, intercrystalline? microporous, vugs, ????"*	On p. 12 line 14 it is written "The highly permeable, extensively dolomitized reef zones represent promising reservoirs for hydrothermal utilization with predominantly convective heat and laminar fluid flow." It is therefore unclear as to what extent this question refers to this sentence.	No changes possible.
Referee 4 – p.12 line 14	*"why? this is an important conclusion but there is no real demonstration of the heat transport and flow behaviour"*	As mentioned in the sentence before, this conclusion was made according to the classification of the thermofacies concept (Sass and Götz, 2012). The application of the thermofacies concept is useful in an early exploration stage or in cases where detailed reservoir information is not available. This concept allows a first characterization (whether it is a petrothermal, transitional or hydrothermal reservoir), but does not replace further investigation. Due to the high number of well data (several thousand wells) that need to be evaluated for a more detailed assessment, this point is not further elaborated in the manuscript and will be part of the next phase of the project. This conclusion takes also previous studies into account regarding diagenesis (Machel and Buschkuehle, 2008), fluid flow and hydraulically connected areas (Michael et al., 2003; Rostron et al., 1997; Bachu et al., 2008) as well as the well data from the oil industry (production data).	No changes. This is explained in the text.

Referee 4 – p. 12 line 19	*“it is not "reservoir scale", it is "plug scale" measurements within reservoir units”*	Accepted.	Line 19 on page 12 was changed to: "Regarding the rock property measurements (core sample scale) of the Leduc Formation (Fig. 9 and 10) at reservoir scale they indicate rather a homogenous matrix (with permeability deviating by three orders of magnitude and porosity varying between 5 to 10 %), in rocks comprised predominantly of stromatoporoid- and coral-rich grainstones/wackestones to floatstones/rudstones. Regarding the rock properties at meter scale, permeability and porosity ..."
Referee 4 – p. 12 line 19	*“ambiguous“*	Accepted.	See changes above.
Referee 4 – p.12 line 20	*“5 % of porosity variation for 3 orders of K permeability: does it suggest micro- fracture”*	We identified hairline fractures e.g. in well 5-22 (Leduc Formation, central basin), which has also been observed in the Strachan pool close to the Rocky Mountains (Marquez and Mountjoy, 1996). These fractures form networks throughout the rock matrix and might explain higher permeability values.	No changes. It is described in chapter 5.1 and Discussion and Conclusions.
Referee 4 – p. 12 line 28	*“what do you mean by "apparent" K?”*	See answer below.	See changes below.

Referee 4 – p.12 line 31	*“ "intrinsic" K ?”*	After Languth and Voigt (2004) the permeability describes the hydraulic parameters of an aquifer. When different fluids (oil, gas, water) occur in a reservoir, the specific, absolute or intrinsic permeability becomes important. The intrinsic permeability describes the aquifer matrix only and does not consider fluid specifications. Permeability was measured with a column permeameter and a mini permeameter, which is a variation of the column permeameter (Hornung and Aigner, 2004). Both devices are gas driven, which allows quick, contaminant-free and non-destructive measurements (Filomena et al., 2014). The column permeameter measures the intrinsic permeability after Klinkenberg (1941). Thereby the intrinsic permeability corresponds to the effective gas permeability of air under infinitely high pressure. The calculation is based on Darcy’s law, supplemented by the addition of compressibility and viscosity of gases. As it’s not possible to determine the permeability under infinitely high pressure (Jaritz, 1999), the column permeameter measures the apparent gas permeability of air with at least five pressure stages from 1000 to 5000 mbar. Afterwards the intrinsic permeability is calculated from the apparent permeability using the Klinkenberg method (1941).	This section in Material and Methods (p. 7, l. 5) was changed to: "Matrix permeability of the outcrop samples was determined with a column permeameter using different air pressure levels from 1 to 3 bar. This method is based on Darcy’s law enhanced by factors for compressibility and viscosity of gases (Jaritz, 1999). It allows calculation of the intrinsic permeability (Ki) from apparent permeability (Ka) by using the Klinkenberg method (Klinkenberg, 1941). Thereby, intrinsic permeability describes the aquifer matrix only and does not consider fluid properties (Languth and Voigt, 2004). The intrinsic permeability corresponds to the effective gas permeability of air under infinitely high pressure. As it is not possible to determine permeability under infinitely high pressure, the column permeameter measures the apparent gas permeability of air with at least five pressure stages (Jaritz, 1999). Afterwards, the apparent permeability is plotted in the Klinenberg plot to calculate the intrinsic permeability. Measurement accuracy varies from 5 % for highly permeable rocks (K ≥ 10-14 m²) to 400 % for impermeable rocks (K ≤ 10-16 m²) (Filomena et al., 2014).”
Referee 4 – p.13 line 7	*“a missing topic in this interesting chapter is the "upscaling-donwscaling" of the properties (reservoir and geothermal)."*	Accepted. See Answer above.	See changes below.

Referee 4 – p.13 line 7	*"there are no measurements or estimation of properties at greater scale than the plugs; so all the extrapolation made from plug measurements to larger scale are implicitely based on averaging and assuming some level of "stationnarity" within stratigraphic units or sedimentary units. Another implicit assumption is that rock properties statistics are not dependent of sample size (no "support effect"). Certainly not the case for permeability in carbonate reservoirs! All these assumptions should be discussed prior to the conclusive statement on the geothermal potential and extrapolation of core plug data."*	Accepted. Porosity and permeability is highly variable within the reservoir. In our manuscript we focused on the core sample scale. We will consider this point.	There must be a misunderstanding here: We did not upscale any properties here. We correlated existent data with our measurements. At reservoir scale meant: From base to top of the Reservoir and the distribution within the basin. There is a huge data set of porosity and permeability available and combined with core analysis from literature, they indicate that the formation is relatively homogenous within the basin (= the range of porosity and permeability at plug scale, nearly everywhere the same grade of dolomitization). Is is to mention that the AccuMap data base predominantly provides data for high porous reservoir sections. Unfortunately, there is no data available for the analyzed wells of the Lobstick, Dismal Creek and Bigoray Member. Therefore it would not be very representative to start the upscaling with the data set presented in this study. More data is needed and probably own porosity and permeability measurements for formations where no data exists. As the outcrops we found in the Front Ranges show distinct differences compared to the reservoir core samples, we have decided that the analogue samples are not useful for geothermal modeling. Therefore we did not consider any scale effects. The outcrop analogue plugs have predominantly a size of 40 mm in diameter, but also 25 mm or 64 mm. We could not indicate any significant size dependent errors in the measurement results at this sample size or within this data set. I think the diagenetic overprint is to high and to variable to identify such errors and affects the results the most. This will be also a critical point for the histograms and variograms presented in your work. I agree that bigger samples are always better to reflect the outcrops/reservoir properties and that small samples cannot represent bigger fracture zones or karstification. It is clear that plugs measurements most likely underestimate the outcrop/ reservoir permeability.

Referee 4 – p.13 line 7	*" you might add histograms of diffrent properties for the various stratigraphic units and facies, to help the discussion on upscaling"*	Thank you very much for this kind advice. We will consider this point during revision of the manuscript. Histograms of the different rock properties might be helpful regarding the upscaling discussion, but they do not replace the plots presented in this manuscript. Figure 7 shows the correlation of the rock properties and Figures 8 to 10 give a first impression how the properties vary within the reservoir, whereby we focused on the latter.	We decided not to defocus the aim of this paper. As explained above, porosity and permeability data is not available for all analyzed wells. Upscaling with this data set would not be very representative. More data provided in the AccuMap data base needs to be evaluated, which is beyond of the scope of this study. Therefore we added just a brief summary about the next steps and the processing of the data concerning upscaling: The here presented data set was analyzed under lab conditions (20 °C) and represents matrix properties only (representative at cm-scale, macroscale). It is to emphasize that rock property measurements can differ with samples size. Measurements at plug scale do not represent larger features as large vugs and molds (bigger than sample size), karstification or fracture zones and most likely underestimate porosity or permeability of the outcrop/reservoir. Especially in carbonate reservoirs porosity and permeability can be very variable. In order to utilize the rock properties in a geological model, they need to be corrected for reservoir conditions and subsequently transferred to reservoir scale (macroscale). For example thermal conductivity: With given information about reservoir fluid properties and porosity, thermal conductivity can be recalculated for water-saturated conditions (Clauser and Huenges, 1995; Popov et al., 2003). Temperature dependency models are used to transfer thermal properties to reservoir conditions as described in Vosteen and Schellschmidt, (2003) and Sommerton, (1992). In general, thermal conductivity increases with increasing water content, porosity and pressure, but decreases with increasing temperature (Clauser and Huenges, 1995). For example, thermal conductivity of matrix dominated limestones of the Jurassic Malm Formation in Southern Germany ranges between 1.35 – 2.62 W m^{-1} K^{-1} at 20 °C and dry conditions, 1.60 – 2.79 W m^{-1} K^{-1} at 20 °C and saturated conditions and 1.41 – 2.25 W m^{-1} K^{-1} at reservoir conditions (150°C). Geothermal reservoirs have a smaller margin to be economically profitable than oil reservoirs. Therefore Rühaak et al. (2015) tested different upscaling procedures for thermal conductivity to testify their accuracy. Thereby the intention is to keep as much of the small scale information as possible. The results indicate that harmonic and geometric mean upscaled values reflect most accurately local values. A reliable porosity/permeability prediction is crucial for reservoir characterization and modeling (Borogomano et al., 2008) and mostly has to be carried out with a limited number of core measurements. Upscaling

			techniques for porosity, permeability and hydraulic conductivity have been subject of several studies and are described in Clauser (1992), Renard and de Marsily (1997) and Farmer (2002). Previous studies in the WCSB analyzed a high amount of well data and used the calculation of arithmetic and geometric mean values to upscale their parameters from plug to reservoir scale (Weides et al., 2013, Ardakani and Schmitt, 2016). Borgomano et al. (2013) analyzed the porosity-permeability relationship of plug samples combined with detailed facies analysis to identify the predictability of these parameters. Additionally, the creation of vertical and horizontal histograms and variograms can help to identify the heterogeneity, anisotropy and lateral distribution of the properties and whether the upscaling from plug to reservoir scale is linear or not.
Referee 4 – p.28	*"I would add some histograms, for different geologicl units and facies , etc...that would help to discuss the upscaling issue in the conclusion"*	Same answer as above.	See changes above.
Jacek Majorowicz – C2 line 7	"*1.The reference should be Weides and Majorowicz (2014) as given below in the References.*"	I apologize for this mistake. It has been corrected accordingly.	It was corrected on page 2, line 32, page 3, line 2 and 4, page 4 , line 7, page 18, line 16

Jacek Majorowicz – C2 line 9	"*2, Heat flow in the cited map in Weides and Majorowicz (2014, their Fig. 3) for the studied area of the Alberta basin is not reaching 80 mW m-2 It is less than 70mW m2. The heat flow in the WCSB generally ranges from 30 to 100 mW/m2, being 60.4 mW/m2 on average according to Weides and Majorowicz (2014). The heat flow values has been corrected for paleoclimatic surface temperature forcing (Majorowicz et., al. 2012).*"	Thank you very much for this correction. The associated section in chapter "1 Introduction" in page 3 line 1 has been changed to: "The area around the town site of Hinton in the western region of the Alberta Basin (Fig. 1) is of particular interest because well data analysis indicates flow rates of more than 400 $m^3 h^{-1}$ and temperatures up to 150 °C at depths of approximately 5 km (Lam and Jones, 1985)." General information about the geothermal gradient and heat flow in the WCSB was added to page 2, line 30: "This appears feasible because, although this province is characterized as a 'low enthalpy region' (Grasby et al., 2012; Lam and Jones, 1985 and 1986) with a moderate average geothermal gradient of 33.2 °C km^{-1} and an average heat flow of 60.4 W m^{-2} in the WCSB, recent studies using data from several tens of thousands of oil and gas wells suggest that at least some of the Upper Devonian carbonate aquifers are suitable for geothermal utilization (Weides and Majorowicz, 2014)".	line 1 on page 3 has been changed to: "The area around the town site of Hinton in the western region of the Alberta Basin (Fig. 1) is of particular interest because well data analysis indicates flow rates of more than 400 m^3 h-1 and temperatures up to 150 °C at depths of approximately 5 km (Lam and Jones, 1985)."; page 2, line 30 has been changed to: "This appears feasible because, although this province is characterized as a 'low enthalpy region' (Grasby et al., 2012; Lam and Jones, 1985 and 1986) with a moderate average geothermal gradient of 33.2 °C km-1 and an average heat flow of 60.4 W m-2 in the WCSB, recent studies using data from several tens of thousands of oil and gas wells suggest that at least some of the Upper Devonian carbonate aquifers are suitable for geothermal utilization (Weides and Majorowicz, 2014)."

Jacek Majorowicz – C2 line 15	*:"The attached average geothermal gradient map (Fig.1) shows that there are much 'hotter' areas in the WCSB in Alberta and these are to the north and east of deep part of the foreland basin in the Hinton area."*	This is correct. The two carbonate complexes were selected because 1) A lot of communities in Alberta are located in this area (this applies especially for the Rimbey-Meadowbrook Reef Trend), 2) There is increasing public interest in geothermal energy utilization in the Hinton-Edson area (Southesk-Cairn Carbonate Complex), 3) the general growing interest in repurposing abandoned oil and gas wells to find new possibilities to reduce the demand of fossil fuels and to reduce CO_2-emissions, 4) there are similarities in rock type, depth and structure of the Devonian aquifer systems with the Jurassic Malm-aquifer in the Southern German Molasse Basin, which offers the possibility of knowledge transfer between Alberta and Germany.	We added the following sentences to page 4 for a better understanding: Page 4 line 20: "Therefore the carbonate platforms are in focus of interest due to the general increasing public interest in repurposing abandoned oil and gas wells." Page 4 line 27:" Within the WCSB, the geothermal gradient and heat flow varies from 20 °C km^{-1} to over 55 °C km^{-1} and 30 mW m^{-2} to 100 mW m^{-2}, respectively (Majorowicz et al., 2012; Weides and MAjorowicz, 2014). Areas with higher heat flow values are identified in the northern part of the basin. Compared to the study area, these zones are sparsely populated and thus not chosen for this pilot study.
Jacek Majorowicz – C2 line 20	"*However, such deep wells are expensive and economics of drilling two 5km wells into the deepest sedimentary horizons will end up with extremely high mineralized waters and rather poor porosity/permeability (Lam and Jones, 1985)."*	This pilot study was intended to be an initial inquiry into the the Upper Devonian carbonates with respect to geothermal utilization and to create an initial data set of rock properties relevant to geothermal exploration and modelling. To assess the economic feasibility of this reservoir more data is needed, e.g. the corrected heat flow and temperature data (Majorowicz et al., 2012; Nieuwenhuis et al., 2015), salinity, flow rates, potentiometric surfaces, and hydraulic heads to name just a few. The high TDS content in the formation waters of the Leduc and Nisku formations (Rostron et al., 1997; Bachu et al., 2008) is a critical parameter for geothermal production. Therefore, well data provided in the AccuMap or GeoScout databases need to be evaluated and interpreted carefully, which is beyond of the scope of this study. A	See changes above: R1 C2 line 1.

		short section will be added to the chapter “discussion and conclusions” to provide an overview of further steps. We don’t agree with the statement that porosity and permeability are generally poor at these depth levels. According to Amthor et al. (1994), there is an overall decrease of porosity/permeability with depth in the Leduc Formation in the WCSB, but it has also been shown that especially the dolomitized reef sections retain their porosity/permeability compared to limestones at the same depth level or compared to well cores which are located in the shallower parts of the basin. An example is presented in this manuscript: Well 2-36-54-23W5 (>4 km depth), located in the western part of the Southesk-Cairn Carbonate Complex, shows the highest porosity and permeability of all wells in this dataset. Porosity and permeability can be highly variable within aquifers at a local scale. However, it must be taken into account that high porosity and permeability values do not naturally guarantee high flow rates. Therefore, a careful evaluation of the well data and other existing information on the reservoir must be carried out to localize the most promising areas.	

Referee 3 – C2 line 15	3) *Introduction: To suggest that there is a political climate that favours business over environment, and its [sic] doubtful if Alberta will want to transition to a cleaner energy system is simply outrageous – politics does not belong in a science paper. Besides, Albertans have recently elected a government that has one of the most aggressive environmental programs in North America, including implementing the largest carbon tax in Canada. Such statements that speak to the politics of a place the authors do not live in, and to speculate about future decisions Albertan's will make, have absolutely no place in a science paper."*	Climate change is science and policy. Geothermal energy research deals with it. The political background was triggering this research. It is a question of taste if a political statement will belong to a science paper or not. That may stay with R3.	Line 21 to 24 on page 15 was deleted.
Referee 3 – C2 line 29	" *5) Page 3, line 9: what is Malm*?"	Malm" is mentioned 5 times in the MS: 3times referred to as "Upper Jurassic Malm-Aquifer […] in Southern Germany", the other times as "German Malm Formation" and "Malm and Devonian" (p 3, ln 9). – Despite the given explanations and the hint in the immediately following line – (it's a) "regionally extensive carbonate aquifer system(s)" (p 3, ln 10f) – we will make some changes to make it absolutely clear to everybody who will not read to that line: "~~Malm and Devonian~~" "Malm Formation and Devonian Period"	Malm and Devonian was changed to Malm Formation and Devonian Period in line 9 on page 3
Referee 3 – C3 line 10	"*9)Page4,ln2: Delete'literally'and also,use theCanadian spelling of "Centre" not 'Center' as that is the formal spelling of the Core Centre."*	Agreed.	Literally was deleted in line 2 on page 4, Core Research Center was changed to Core Research Centre in line 3 on page 4 and in line 18 on page 6

Referee 3 – C3 line 11	” *10) Page 4, ln 3 “.., results of drill stem test..”*	Agreed.	"results of " was added to line 3 on page 4
Referee 3 – C3 line 19	” *13) Page 4, ln 21: the formal name is ‘Rocky Mountains’*”	Accepted.	Rockies was changed to Rocky Mountains in line 21 on page 4
Referee 3 – C3 line 23	” *16) Page 9, ln 11: need ref for timing of larimide*”	Accepted.	We changed line 9 on page 9 to: “These fractures probably resulted from overpressuring of the well-sealed reservoir during deep burial, driven by thermal cracking of crude oil to gas and possibly aided by tectonic compression, both happening simultaneously during the Late Cretaceous - Early Tertiary and coinciding with the peak phase of the Laramide orogeny (appr. 80 -55 Ma., English and Johnston, 2004).” We changed line 19 on page 5 to: “This region of the WCSB has undergone four orogenies since the Devonian period (1. Antler (Devonian-Carboniferous), 2. Sonoma (Late Permian), 3. Columbian (Jurassic-Early Cretaceous) and 4. Laramide (Mid-Late Cretaceous-Tertiary); Machel, 2010), which ultimately resulted in the wedge-shaped, triangular geometry in cross section of the foreland basin and its sedimentary filling (Fig. 2), now generally referred to as the Alberta Basin.
Further corrections:			
	Table 1: The depth levels of well 2-36 and 16-18 in Table 1 were reversed. The analysed depth interval of well 16-18 is now “2741.00 m to 2779.77 m” and the analysed depth intervals of well 2-36 are “4068.77 m to 4095.00 m” and “4145.00 m to 4165.39 m” as shown in Fig. 9.	The depth intervals were corrected.	

	Table 2 – Perdrix Formation: The number of measured plugs for the density measurements is N = 17.	The table was corrected.	
	Page 6 line 22: It is IHS instead of HIS – also in the references. I apologize for the unfortunate auto correction.	HIS was changed to IHS on page 6 line 22 and in line 13 on page 17.	
	Page 8, line 14: The investigated Leduc Formation mainly represents stromatoporoid and coral-rich reefs and reef margin lithologies with dissolution enlarged vugs and molds.	Changed to: "The investigated Leduc Formation mainly represents intensively dolomitized stromatoporoid and coral-rich reefs and reef margin lithologies with dissolution enlarged vugs and molds.	
	Page 4 line 8	To make the aim of this paper clear: Accurate thermal properties are critical parameters for reliable geothermal assessment (Popov et al., 2016). The aim of this work was to create an initial data set of rock properties (relevant to geothermal modeling) specific to the Upper Devonian aquifer systems which have become of particular interest for geothermal utilization and also for identifying variations of rock properties within the reservoir.	
	Page 2 line 2	We changed 10^{-14} to 10^{-15} to avoid over estimation	
	Page 3 line 14	We added (Fig. 3) for a better understanding.	
	Page 4 line 17	We changed Nisku reef trend to Nisku Reef Trend	
	Page 4 line 18	We changed Both to The	

	Page 6 line 4	We added (D1 – D4, Fig. 3) for better understanding.	
	Page 6 line 16	We changed termophysical to “thermo-“ and added “outcrop”.	
	Page 7 line 4	We added the following explanation: “For direct comparison with the provided data in the AccuMap data base only particle density is presented here”.	
	Page 13 line 21	We replaced > with “up to”, otherwise readers could think that permeability is commonly higher than 10^{-12} m² in the reservoir.”	
	Page 13 line 26	The sentence was deleted, because we added a new section addressing the next steps.	
	Page 15 line 19	We added the following sentence to Acknowledgements: “We would like to thank Jean Borgomano, Jacek Majorowicz and three anonymous reviewers for their constructive comments.”	
	Tables; Figures, Appendix B, References	The sections tables, figures have been modified. Appendix B has been added. References has been actualized.	