

## Table of contents

1	Executive Summary of Phase II.....	1
1.1	Executive Summary of Phase II.....	2
1.1.1	Approach of Phase II .....	2
1.1.2	Outcomes of Phase II.....	3
1.1.3	Recommendations.....	11
2	Introduction.....	12
2.1	Petroleum Systems modeling.....	12
2.2	Geologic Framework and Background.....	12
2.3	Previous models for extension and hydrocarbon generation.....	15
3	Modeling Methods.....	16
4	Model Input and Construction .....	18
4.1	Depth interpretation .....	18
4.2	Stratigraphy.....	20
4.3	Geologic evolution.....	24
4.4	Lithologies .....	36
4.5	Source rocks.....	36
4.6	Crustal rocks .....	38
5	Simple thermal basement models .....	39
5.1	Thick lithosphere .....	40
5.2	Thin lithosphere .....	43
5.3	Variations of timing.....	48
6	Advanced thermal basement models .....	49
6.1	No fluid flow.....	49
6.2	Fluid flow.....	54
6.2.1	Skonun source rocks .....	55
6.2.2	Cretaceous source rock .....	60
6.2.3	Jurassic source rocks.....	69
7	Discussion.....	84
7.1	Sensitivity to various parameters.....	84
7.2	Migration.....	84
7.3	Trapping.....	85
7.4	Comparison to other models.....	86
7.5	Uncertainties regarding the Jurassic source rocks .....	90
7.6	Erosion, timing and amount of eroded material.....	91
8	Conclusions.....	92
9	References.....	93
10	Glossary .....	99
11	Appendix.....	101
11.1	A.1 –Depth section of seismic reflection line 88-05.....	102

## List of Figures

- Figure 1 Map of the Queen Charlotte Basin region showing the present day maturity zones of the Neogene sediment package and the outlines of the offshore region and the Hecate and Queen Charlotte Basin. The structural information is from Rohr and Dietrich (1992). ..... 1
- Figure 2. Study area. Seismic reflection line 88-05 across Hecate Strait (red line) was modelled. It crossed the location of the Sockeye B-10 well, which showed oil stains. The blue area shows the part of the QCB covered in this study, based on mapping of Tertiary sediment thickness (Rohr and Dietrich, 1992). Thin lines show location of seismic reflection survey (Rohr and Dietrich, 1990). Queen Charlotte Fault (QCF), Queen Charlotte Islands (QCI) and Vancouver Island (VI) are marked. .... 2
- Figure 3. Transformation ratio summarized for all source rocks today predicted along seismic reflection line 88-05. Kerogen in the Jurassic Sandilands and Ghost Creek source rocks (type II) are predicted to have largely been transformed into hydrocarbon. Kerogen in the Cretaceous Haida source rock (type III) is predicted to be partially transformed in the deepest central Basin D, and kerogen in the Skonun source rock (type III) is predicted to be largely immature. Only the deepest part of the Skonun source rock is predicted to reach maturity in the central part of the model along seismic reflection line 88-05. Location of Sockeye B-10 well is marked at ca. 10000 m. .... 5
- Figure 4. Detail from Figure 5 shows predicted migration of hydrocarbon around Sockeye B-10 well. Red arrows indicate direction of migration and show the accumulation of hydrocarbons in an anticline trap scenario today. Base of arrow is in cell that hydrocarbon is flowing from; length of arrow indicates velocity (m/Ma). Arrows indicate predicted direction and speed of hydrocarbon migration. Siltstones are coloured light purple; other coloured areas indicate predicted in situ hydrocarbon saturation in estimated pore spaces. .... 6
- Figure 5. Computed evolution of the marine Jurassic source rocks, the Sandilands and Ghost Creek formations in the Kunga and Maude groups, respectively. See caption of Figure 6 for explanation of colours and symbols. .... 7
- Figure 6. Computed evolution of the terrestrial Cretaceous Haida source rocks. Arrows indicate predicted direction and speed of hydrocarbon migration. Siltstones are coloured light purple; other coloured areas indicate predicted in situ hydrocarbon saturation in estimated pore spaces. .... 8
- Figure 7. Computed evolution of the terrestrial Neogene Skonun source rocks. The algorithm computes that hydrocarbon generation would have begun by 15 Ma. Only small areas of the source rock layers are predicted to be saturated <5%. .... 9
- Figure 8. Areas where kerogen in the investigated source rocks are predicted to be more than 50% transformed into hydrocarbon. For the Cretaceous source rocks of the Haida Formation scenarios for both types of kerogen are presented. The red line marks the location of line 88-05. N.B. The location of the Mesozoic rocks under Hecate Strait has not been mapped; we ran the model assuming a uniform thickness of this source layer underneath Neogene basin fill mapped by Rohr and Dietrich (1992), see Section 4.2. .... 10
- Figure 9. Location map of the Queen Charlotte Basin, offshore British Columbia with seismic reflection data collected in 1988 (after Rohr and Dietrich, 1990). Part of line 88-05 (marked in red. was used for the 2D basin modelling. .... 13
- Figure 10. Sediment thickness map of Tertiary sediments (after Rohr and Dietrich, 1992). The coloured insert shows an enlarged area around line 88-05, which images several sub basins. Thumbnail of reflection profile shows these basins, see Appendix A. .... 14
- Figure 11. Seismic velocity vs. depth chart as measured by a sonic log in the Sockeye B-10 well (blue diamonds) and interpreted from stacking velocities from the seismic reflection data close to the well (red triangles). .... 19

Figure 12. Interpretation of interval velocity along line 88-05 from stacking velocities. Interval velocities were used to convert the seismic reflection data from time to depth. ....	20
Figure 13. Stratigraphy used in models. Age of units is on the left and names of layers are on the right. ....	21
Figure 14. Detail of seismic line 88-05. A steep fault zone separates different stratigraphic sections in sub-Basins A and B. ....	22
Figure 15. Detail of seismic line 88-05. Mesozoic rocks are interpreted to exist below the blue line. Their amplitudes fade out and we cannot detect the base of these beds. We have interpreted a fault to exist below them, but below 4. s it is not well constrained.....	24
Figure 16. Grid constructed from isochrons; during modelling computations are performed for each cell. Basins A to E are separated by eastward dipping normal faults. Transparent red area is shown enlarged in Figure 17. ....	25
Figure 17. Enlarged view of grid cells spanning red area in Figure 16. Onlapping horizons are marked in blue, erosional events are marked in red. ....	25
Figure 18. Cross-section at 169 Ma shows sediments deposited in the Jurassic and Triassic. We defined them to be uniform in thickness at 0 Ma (see above). Rifting of these layers will smooth out the lateral thickness variations. Block faulting in the Triassic and Cretaceous disrupted the original beds, but these structures have not been mapped under Hecate Strait and are not reproduced in the model.....	26
Figure 19. We added layers to represent the Cretaceous Longarm Formation and Queen Charlotte Group. Rifting began with a symmetric Basin, D, opening up between 26 and 40 km; we interpret Basin D to represent the initiation of the rifting and its initial infill to consist of Skonun Formation interlayered with basalt flows.....	27
Figure 20. 22.5 Ma. Within a few million years more extensional faults became active creating sub-Basins B, C, and E with lacustrine sedimentation. Note that the model expanded horizontally as rifting continued.....	28
Figure 21. 17.25 Ma. Faulting and sedimentation continued in the sub-basins while non-deposition and erosion occurred over the basement high and continued over the next few million years. ....	29
Figure 22. 14.4 Ma. Motion on the western bounding fault of basin D (~25 km) dominated activity; smaller amounts of subsidence and sedimentation occurred in the other sub-basins. This is near the beginning of post –rift sedimentation according to an analysis of well logs by Higgs (1991) .....	30
Figure 23. 12.5 Ma. More erosion and a hiatus occurred over the basement high ~40 km, subsidence continued elsewhere. The fault at 6 km began a period of activity, but motion on the fault at 25 km had slowed considerably. ....	31
Figure 24. 9.5 Ma. The fault at 6 km was dormant and a westward thickening wedge of sediment was deposited on the western end of the line. The basement high continued with non-deposition. Sediments in the Sockeye B-10 well are dominantly marine above this horizon (Figure C1).....	32
Figure 25. 6 Ma. Differential movement along the fault at ~15 km affected sedimentation patterns and sedimentation began on the basement high. Non-subsidence at ~ 10 km simulates formation of an anticline. ....	33
Figure 26. 4 Ma. Differential motion along the fault at ~15 km has stopped and non-subsidence or uplift has been occurring at the western end of the model. Subsidence mainly occurred in central Hecate Strait. ....	34
Figure 27. 0 Ma. Location of the Sockeye B-10 well is shown. The sedimentation pattern established by 4 Ma has continued to the present day with deposition in the central basin and non-deposition or uplift occurring in the west. The areas of subsidence and sedimentation change in time from being in fault bound sub-basins to being more continuous but disrupted by non-subsidence first over the basement high between 40-48 km and most recently at the edges of the basin .....	35

Figure 28. Simplified lithologic section for the basin today. ....	36
Figure 29 Inferred distribution of potential source rocks under seismic reflection line 88-05 today. ....	37
Figure 30. Source rocks as defined for the 2D basin modeling with Temis2D™ software. ....	37
Figure 31. It has to be stated that an analysis of the actual kerogen within the available source rocks would provide very valuable information for the basin modeling (see also section 6.2).....	37
Figure 32. Definition of kerogen type II (marine), inferred to be dominant within the Jurassic source rocks. This kerogen is also used by the Temis2D™ software to calculate vitrinite reflectance (%R <sub>o</sub> ). ....	38
Figure 33. Physical properties of the lithosphere employed during basin modelling using Temis2D™ software. ....	38
Figure 34. Definition of the stretching factor ( $\beta$ ) along the modelled section after Dehler et al. (1997). ....	39
Figure 35. Calculated crustal thickness (red and magenta layers) after rifting of thick lithosphere model. ....	40
Figure 36. Assumed thermal state of plate at 245 Ma prior to deposition of Jurassic sediments. Thickness of the entire plate is shown; the dashed line marks approximate depth of 1000°C isotherm. ....	40
Figure 37. Computed thermal state of plate shortly after initiation of rifting. Legend as in Figure 36. ....	41
Figure 38. Computed thermal state of plate while rifting, 21 Ma. Note that this model employing the simple rift option, expanded horizontally as rifting continued. Legend as in Figure 36. ....	41
Figure 39. Computed thermal state of plate at the end of rifting, 17.25 Ma. Legend as in Figure 36. ....	41
Figure 40. Computed thermal state of plate ca. 5 Ma after end of rifting. Cooling of plate has lowered the isotherms and lateral heterogeneity due to variable rifting has diminished. Legend as in Figure 36. ....	42
Figure 41. Computed thermal state of plate today. Legend as in Figure 36. ....	42
Figure 42. Measured values of vitrinite reflectance (%R <sub>o</sub> ) in the Sockeye B-10 well compared to values calculated for a plate model based on Dehler et al., 1997. It is obvious that the computed maturation and the temperature profile are significantly too low. ....	43
Figure 43. Calculated crustal thickness (red and magenta layers) after rifting of thinner lithosphere model; initial plate thickness was 35 km. ....	44
Figure 44. Assumed thermal state of thinner plate model at 245 Ma, prior to deposition of Jurassic sediments. Thickness of the entire plate is shown. Approximate depth of 1000°C isotherm is marked by the dashed line. Note the difference in scale of the depth axis as compared to Figure 36. ....	44
Figure 45. Calculated thermal state of thinner plate shortly after initiation of rifting at 24 Ma. Legend as in Figure 44. ....	45
Figure 46. Calculated thermal state of thinner plate during rifting at 21 Ma. Note that the model employing the simple rift option expanded horizontally after rifting started. Legend as in Figure 44. ....	45
Figure 47. Calculated thermal state of thin plate at the end of rifting 17.25 Ma ago. Legend as in Figure 44. ....	45
Figure 48. Calculated thermal state of plate ca. 5 Ma after end of rifting. Legend as in Figure 44. ....	46
Figure 49. Calculated thermal state of plate today. Legend as in Figure 44. ....	46
Figure 50. Calibration of the thinner plate model to thermal data measured in the Sockeye B-10 well. ....	47

Figure 51. Cross-section of calculated vitrinite reflectance (%R <sub>o</sub> ) for thin plate model. Cells of the model representing source rocks have been superimposed. The Sockeye B-10 well is located in Basin B at ca. 9 km along the profile. Dashed lines reflect averaged maturation zones within the basin. With the exception of the easternmost part of the model, where Mesozoic rocks occur in much shallower levels a fairly uniform maturation with depth is predicted. ....	47
Figure 52. Calculated vitrinite reflectance (%R <sub>o</sub> ) for the Sockeye B-10 well assuming rifting of a thin plate a) between 24 and 17 Ma, b) between 30 and 23 Ma, c) 25% older isochrons and d) Shell (1968b) stratigraphy. Blue diamonds are values of vitrinite reflectance (%R <sub>o</sub> ) measured in the well. ....	48
Figure 53. Calculated crustal thickness after rifting using the advanced thermal basement rifting algorithm provided by the Temis2D™ software. ....	49
Figure 54. Assumed thermal state at 245 Ma of advanced basement plate model with fluid flow, prior to deposition of Jurassic sediments. Thickness of the entire plate is shown. In the advanced rifting option the cells in the model were not stretched and the physical width of the model did not change over time. This allowed computation of fluid flow within the model. Legend as above (Figure 44); approximate depth of 1350°C isotherm is marked by solid line. Note the difference in scale of the depth axis compared to Figure 36 and Figure 44. ....	50
Figure 55. Calculated thermal state of advanced basement plate model shortly after initiation of rifting, 24 Ma. Sediment fill of rift basin in combination with subsidence affected isotherms. Legend as in Figure 44. Approximate depth of 1350°C isotherm is marked by solid line. ....	50
Figure 56. Calculated thermal state of advanced basement plate model during rifting at 21 Ma. Isotherms rise according to the amount of stretching (β factor, see Figure 34). Legend as in Figure 44. ....	51
Figure 57. Calculated thermal state of advanced basement plate model at the end of rifting at 17.25 Ma. Isotherms at their shallowest levels: 10 km at Basin D for the 600°C, 15 km for the 1000°C, and 24 km for the 1350°C isotherm. Legend as in Figure 44. ....	51
Figure 58. Calculated thermal state of plate ca. 5 Ma after rifting finished. Cooling of plate has lowered the isotherms and smoothed out lateral heterogeneity caused by variable rifting. Legend as in Figure 44. ....	51
Figure 59. Calculated thermal state of plate today. Due to continued cooling the 1350°C has been lowered to approximate 42 km and lateral variations of the thermal structure have mostly been smoothed out. Legend as in Figure 44. ....	52
Figure 60. Heat flow history of grid cells from the base of the sediments at different distances along the profile expressed in kilometres. Rifting began at 24 Ma and was finished by 17.25 Ma when cooling began. Periodicity of some of the graphs (45, 50, 60 km) reflects the blanketing effect of rapid deposition of Upper Miocene sediments and/or rapid erosion in the eastern part of the model. ....	52
Figure 61 Calibration of different plate models at the location of the Sockeye B-10 well. ....	53
Figure 62. Cross-section of calculated vitrinite reflectance (%R <sub>o</sub> ) for advanced basement plate model including fluid flow and using a plate thickness of 50 km. Superimposed are the cells of the model representing source rocks. The Sockeye B-10 well is located in Basin B at approximately 9 km. Dashed lines reflect averaged maturation zones within the basin. With the exception of the easternmost part of the model, where Mesozoic rocks occur in much shallower levels a fairly uniform maturation with depth is predicted. ....	53
Figure 63. Region where more than 50% of the kerogen in the Skonun source rocks (type III) are predicted to be transformed into hydrocarbon based on computations of 2D models along line 5 (red line). ....	56
Figure 64. Comparison of computed liquid hydrocarbon saturation and expulsion from Skonun Formation source rocks. Models presented in the panels on the left (a, c) assume the	

organic matter to be of marine origin (type II kerogen), while models presented in the panels on the right (b, d) assume the organic matter to be mainly terrestrial in origin (type III kerogen). Colours refer to liquid saturation and arrows represent expulsion of hydrocarbons. Expulsion is set to start at a saturation of 2% and has a maximum possible saturation of 98%). The base of the arrow indicates the cell from which migration is occurring; its size reflects speed of migration. Siltstones (effective seals) are coloured light purple. ....	57
Figure 65. Comparison of computed total generated hydrocarbon in kg/t (colour scale) originating from Skonun Formation source rocks. Models presented in the panels on the left (a, c) assume the organic matter to be of marine origin (type II kerogen), while models presented in the panels on the right (b, d) assume the organic matter to be mainly terrestrial in origin (type III kerogen).....	58
Figure 66. Comparison of computed mass of HC / mass of rock (colour scale) derived from the Skonun source rocks for today. Model presented in the panel on the left (a) assumes the organic matter to be of marine origin (type II kerogen), while model presented in the panel on the right (b) assumes the organic matter to be mainly terrestrial in origin (type III kerogen). Siltstones (effective seals) are coloured light purple.....	58
Figure 67. Calculated transformation ratio within the Skonun source rocks today. Model presented in the panel on the left (a) assumes the organic matter to be of marine origin (type II kerogen), while model presented in the panel on the right (b) assumes the organic matter to be mainly terrestrial in origin (type III kerogen).....	59
Figure 68. Early Albian (left) and Cenomanian (right) depositional environment, after Haggart (1991). The yellow shaded area marks the terrestrial depositional environment separated by the shoreline (blue) from marine conditions in the southwest. Southwestern end of seismic reflection line 88-05 is marked.....	60
Figure 69. Region where kerogen in the Cretaceous Haida source rocks (kerogen type III) are predicted to be more than 50% transformed into hydrocarbon based on computations of 2D models along line 88-05 (blue line). As these source rocks could contain mainly type II or type III kerogen, scenarios for both types are presented. N.B. The location of Haida rocks under Hecate Strait has not been mapped. The model assumed a uniform thickness of the Haida source layer, see Section 4.2.....	63
Figure 70. Comparison of computed liquid hydrocarbon saturation and expulsion from Haida Formation source rocks. Models presented in the panels on the left (a, c) assume the organic matter to be of marine origin (type II kerogen), while models presented in the panels on the right (b, d) assume the organic matter to be mainly terrestrial in origin (type III kerogen). Colours refer to liquid saturation which has a maximum possible value of 98%. Arrows represent expulsion of hydrocarbons; which was set to start at a saturation of 2%. The base of the arrow indicates the cell from which migration is occurring; its size reflects speed of migration. Siltstones (effective seals) are coloured light purple. ....	64
Figure 71. Comparison of computed liquid hydrocarbon saturation and expulsion from Haida Formation source rocks. Models presented in the panels on the left (a, c) assume the organic matter to be of marine origin (type II kerogen), while models presented in the panels on the right (b, d) assume the organic matter to be mainly terrestrial in origin (type III kerogen). Colours refer to liquid saturation which has a maximum possible value of 98%. Arrows represent expulsion of hydrocarbons; which was set to start at a saturation of 2%. The base of the arrow indicates the cell from which migration is occurring; its size reflects speed of migration. Siltstones (effective seals) are coloured light purple. ....	65
Figure 72. Comparison of computed liquid hydrocarbon saturation and expulsion from Haida Formation source rocks. Models presented in the panels on the left (a, c) assume the organic matter to be of marine origin (type II kerogen), while models presented in the panels on the right (b, d) assume the organic matter to be mainly terrestrial in origin (type III kerogen). Colours refer to liquid saturation which has a maximum possible value of	

- 98%. Arrows represent expulsion of hydrocarbons; which was set to start at a saturation of 2%. The base of the arrow indicates the cell from which migration is occurring; its size reflects speed of migration. Siltstones (effective seals) are coloured light purple. ... 66
- Figure 73. Comparison of computed total generated hydrocarbon in kg/t (colour scale) originating from Haida source rock for today. Model presented on the left (a,) assumes the organic matter to be of marine origin (type II kerogen), while model presented on the right (b) assumes the organic matter to be mainly terrestrial in origin (type III kerogen). ..... 67
- Figure 74. Comparison of computed mass of HC / mass of rock (colour scale) derived from the Haida source rock for today. Model presented in the panel on the left (a) assumes the organic matter to be of marine origin (type II kerogen), while model presented in the panel on the right (b) assumes the organic matter to be mainly terrestrial in origin (type III kerogen). Siltstones (effective seals) are coloured light purple..... 68
- Figure 75. Comparison of calculated transformation ratio (colour scale) within the Haida source rock today. Model presented in the panel on the left (a) assumes the organic matter to be of marine origin (type II kerogen), while model presented in the panel on the right (b) assumes the organic matter to be mainly terrestrial in origin (type III kerogen). ..... 68
- Figure 76. Areas where more than 50% of the type II kerogen in the Jurassic source rocks are predicted to have been transformed into hydrocarbons. The red line marks the location of line 88-05. N.B. The location of Jurassic rocks under Hecate Strait has not been mapped. We ran the model assuming a uniform thickness of this source layer, see Section 4.2. .. 71
- Figure 77. Comparison of computed liquid hydrocarbon saturation and expulsion from Jurassic source rocks in the Ghost Creek and Sandilands formations. Models presented in the panels on the left (a, c) assume the organic matter to be of marine origin ( type II kerogen), while models presented in the panels on the right (b, d) assume the organic matter to be mainly terrestrial in origin (type III kerogen). Colours refer to liquid saturation which has a maximum possible value of 98%. Arrows represent expulsion of hydrocarbons; which was set to start at a saturation of 2%. The base of the arrow indicates the cell from which migration is occurring; its size reflects speed of migration. Siltstone beds (effective seals) are coloured light purple ..... 72
- Figure 78. Comparison of computed liquid hydrocarbon saturation and expulsion from Jurassic source rocks in the Ghost Creek and Sandilands formations. Models presented in the panels on the left (a, c) assume the organic matter to be of marine origin (type II kerogen), while models presented in the panels on the right (b, d) assume the organic matter to be mainly terrestrial in origin (type III kerogen). Colours refer to liquid saturation which has a maximum possible value of 98%. Arrows represent expulsion of hydrocarbons; which was set to start at a saturation of 2%. The base of the arrow indicates the cell from which migration is occurring; its size reflects speed of migration. Siltstone beds (effective seals) are coloured light purple ..... 73
- Figure 79. Comparison of computed liquid hydrocarbon saturation and expulsion originated from Jurassic source rocks in the Ghost Creek and Sandilands formations Models presented in the panels on the left (a, c) assume the organic matter to be of marine origin (type II kerogen), while models presented in the panels on the right (b, d) assume the organic matter to be mainly terrestrial in origin (type III kerogen). Colours refer to liquid saturation which has a maximum possible value of 98%. Arrows represent expulsion of hydrocarbons; which was set to start at a saturation of 2%. The base of the arrow indicates the cell from which migration is occurring; its size reflects speed of migration. Siltstone beds (effective seals) are coloured light purple ..... 74
- Figure 80. Comparison of computed liquid hydrocarbon saturation and expulsion originated from Jurassic source rocks. Models presented in the panels on the left (a, c) assume the organic matter to be of marine origin (type II kerogen), while models presented in the panels on the right (b, d) assume the organic matter to be mainly terrestrial in origin (type III kerogen). Colours refer to liquid saturation which has a maximum possible value of 98%.

Arrows represent expulsion of hydrocarbons; which was set to start at a saturation of 2%. The base of the arrow indicates the cell from which migration is occurring; its size reflects speed of migration. Siltstone beds (effective seals) are coloured light purple. ... 75

Figure 81. Comparison of total hydrocarbons in kg/t (colour scale), which are computed to have originated from Jurassic Ghost Creek and Sandilands source rocks. Models presented in the panel on the left (a) assumes the organic matter to be of marine origin (type II kerogen), while model presented in the panel on the right (b) assumes the organic matter to be mainly terrestrial in origin (type III kerogen)..... 76

Figure 82. Comparison of computed mass of HC / mass of rock (colour scale) derived from Jurassic source rocks present today. TOC is the main factor affecting the net amount generated. Model presented in the panel on the left (a) assumes the organic matter to be of marine origin (type II kerogen), while model presented in the panel on the right (b) assumes the organic matter to be mainly terrestrial in origin (type III kerogen). Siltstone beds (effective seals) are coloured light purple. Far greater concentrations of hydrocarbons are predicted to have been generated in the more likely case of marine kerogen in these formations. .... 76

Figure 83. Comparison of computed transformation ratio (colour scale) within Jurassic source rocks today. Model presented in the panel on the left (a) assumes the organic matter to be of marine origin (type II kerogen), while model presented in the panel on the right (b) assumes the organic matter to be mainly terrestrial in origin (type III kerogen). .... 77

Figure 84. Comparison of computed liquid hydrocarbon saturation and expulsion from Jurassic source rocks in the Ghost Creek and Sandilands formations. The hydrocarbon potential (S2) in the models presented here is set to 0.5x and 0.1x the value as above in the panels on the left (a, c) and on the right (b, d), respectively, to reflect the expulsion of hydrocarbon due to an earlier maturation event during the Jurassic. Colours refer to liquid saturation and arrows represent expulsion of hydrocarbons (set to start at a saturation of 2%, maximum possible saturation is 98%). The base of the arrow indicates the cell from which migration is occurring; its size reflects speed of migration. Siltstone beds (effective seals) are coloured light purple. .... 80

Figure 85. Calculated amount of hydrocarbon generated during Tertiary rifting from marine Jurassic source rocks that had been heated ~150 Ma. Model in the left panel assumes a 'pre-maturation' to 50% of the S2-peak, model in the right panel assumes a 'pre-maturation' to 10% the S2-peak. .... 81

Figure 86. Calculated liquid saturation in rocks generated during Tertiary rifting from Jurassic source rocks that had been heated ~150 Ma. Model in the left panel assumes a 'pre-maturation' to 50% of the S2-peak, model in the right panel assumes a 'pre-maturation' to 10% of the S2-peak. .... 81

Figure 88. Computed vitrinite reflectance for fixist and mobilist models. Slight differences exist around 30 Ma, but very little after Tertiary rifting. .... 83

Figure 89. Comparison of calibration of 1D models from Phase I with 2D models from Phase II. The much better fit of the more complex 2D models can be attributed to smaller radiogenic heat production value of basement rocks and inclusion of cooling effects of fluid flow. Vitrinite reflectance measurements from Bustin (1997)..... 86

Figure 90. Comparison of measured vitrinite reflectance values (Bustin, 1997) to values derived from  $T_{max}$  pyrolysis data, as used by Dietrich (1995). Dashed lines show depth to the top of the oil window at 2100m, depths to top of gas window and overmaturity zone as interpreted from the Hannigan et al. models (3550 and 4400 m) and as interpreted from models presented here(3800 and 4900 m)..... 87

Figure 91. Subsidence and hydrocarbon generation for the area of the Sockeye B-10 well, Hecate Strait (modified from Dietrich, 1995). He predicted that the Kunga-Maude strata would generate hydrocarbons over a period of ca. 150 Ma and the lower Skonun Formation would enter the oil window ca. 20 Ma ago. .... 88

Figure 92. Results of 1D basin modelling as presented by Bustin (1997) for the location of the Sockeye B-10 well, modified from Bustin (1997). Panel A shows his assumptions for the evolution of the post rift heat flow to decay by less than 10 mW/m<sup>2</sup> during the 20 Ma following the rifting. Panel B presents the predicted burial history of the syn-rift (36-20 Ma) and the post rift (20-0 Ma) strata. It has to be noted, that no Oligocene sediments have been reported from the well, although Bustin (1997) assumes ca. 2.5 km to be present. Panel C shows measured (black dots, polynomial? fit in red line) and modelled vitrinite reflectance data (blue line), after Bustin (1997). An obvious mismatch of trend lines occurs between 1500 and 3500 m (grey shaded zone). Bustin (1997) calculated the top of the oil window (0.5% R<sub>o</sub>) to be at ca. 1800 m depth (blue line), whereas his own data-based estimate (red line) placed it at ca. 2300 m (see also Figure 90). ..... 89

Figure 93. Transformation Ratio summarized for all major source rocks. Kerogen in the Jurassic Sandilands and Ghost Creek source rocks (type II) are predicted to have largely been transformed into hydrocarbon. Kerogen in the Cretaceous Haida source rock (type III) is predicted to be partially transformed in the deepest central basin and kerogen in the Skonun source rock (type III) is predicted to be largely immature. Only the deepest part of the Skonun source rock is predicted to reach maturity in the central part of the model along seismic reflection line 88-05. Location of Sockeye B-10 well is marked at ca. 10000 m. .... 92

## List of Tables

Table 1. Areal extent of source rock beds predicted to contain kerogen transformed by more than 50%. N.B. The location of the Mesozoic rocks under Hecate Strait has not been mapped; we ran the model assuming a uniform thickness of this source layer, see Section 4.2. .... 9

Table 2. Inferred formation thickness ..... 23