Input Data Used to Generate One-dimensional Burial History Models, Central Alberta, Canada

By Laura N.R. Roberts, Debra K. Higley, and Mitchell E. Henry

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Introduction

The purpose of this report is to provide the sources of data that were used to prepare one-dimensional (1-D) burial history reconstructions at 6 well locations in the central Alberta part of the Western Canada Sedimentary Basin (WCSB) (fig. 1, table 1); the 1-D reconstructions were then used to calibrate a three-dimensional (3-D) model of petroleum systems in the basin (Higley and others, 2005). The 3-D model was generated in order to calculate the relative influences through time of geologic processes that control generation, migration, and accumulation of petroleum. The software used for both 1-D and 3-D modeling was PetroMod1D (version 8.0) of Integrated Exploration Systems GmbH (IES), Germany. The well locations were chosen because they have measured downhole temperature data, either from the modeled well or from a nearby well, and they have measured vitrinite reflectance data from the coal-bearing Mannville Group to aid in calibrating burial history models.

Methods – Burial History

Minimum data input required for the software to calculate burial history curves include (1) age of deposition, generalized lithology, and thickness of stratigraphic units; (2) age and duration of periods of nondeposition or erosion; and (3) lithology and thickness of the eroded intervals. Table 2 shows the age and generalized lithologic and thickness data used to construct the burial history curves at each location. It also lists the interval names that correspond, in general, with intervals that were used in constructing a 3-D geologic model (Higley and others, 2005).

Data sources to assign lithologies and ages of the stratigraphic units include Exploration Staff, Chevron Standard Limited (1979), Clark and Philp (1989), Obradovich (1991), Creaney and Allan (1992), Mossop and Shetsen (1994), Lexicon of Canadian Stratigraphy (1997), and Bloch and others (1999). The Agat Laboratories Table of Formations of Alberta (no date) was also used to estimate ages of stratigraphic units and periods of nondeposition or erosion. Lithologies were generalized for modeling purposes. Thicknesses of stratigraphic units in the subsurface were calculated from tops of units recorded in Riley's well database for Alberta and the IHS Energy Accumap database (2004). In some cases, the stratigraphic unit thicknesses were modified to agree with isopach maps published in the Geologic Atlas of the Western Canada Sedimentary Basin (Mossop and Shetsen, 1994).

Two major erosional events occurred in the WCSB that influenced petroleum generation, migration, and accumulation. The older one is a sub-Mannville erosional unconformity that we assigned an age that began between 368.5 and 197 Ma based on ages of formations below the unconformity and ended about 119 Ma (table 2). Due to uncertainty regarding the possible thickness of the eroded interval represented by this unconformity, we considered the interval to be a period of nondeposition for 1-D modeling purposes. A relatively minor period of nondeposition ocurred betweenn 104 and 100 Ma and is also recorded at all six of the burial history locations (fig. 1). Greatest burial depth was achieved prior to about 58 Ma, as the basin subsided during Laramide deformation. The second major erosional event, caused by late Tertiary regional uplift, then resulted in the removal of an estimated 650 to 1,400 m of strata in the study area. These estimates generally agree with earlier published estimates of eroded thickness for the same area (Hitchon, 1984; Nurkowski, 1984; Bustin, 1991; Issler and others, 1991; Osadetz and others, 1992; and Ravenhurst and others, 1994).

Methods – Thermal History

Data used to calibrate thermal models at each burial history (well) location include the approximate temperatures at the Precambrian surface (Bachu and Burwash ,1994), downhole temperatures, and vitrinite reflectance (%R_o) (fig. 1). Downhole temperature data included uncorrected drillstem test temperatures (IHS Accumap database, 2004) from records of two of the wells (wells 306 and 301) and temperatures from records of wells nearby the other four wells (table 2). Vitrinite reflectance data are from Stasiuk and Fowler (2002) and Stasiuk and others (2002). Measurements of R_o from coal in the Mannville Group (and equivalents) are more reliable than those from other lithologies because coal contains the true vitrinite maceral from which the best reflectance values can be measured. Therefore, we calibrated the burial history models using the measured R_o values in the Mannville and were not concerned if the values of samples at lower stratigraphic horizons, which may not contain true vitrinite, did not match the calculated curve (fig. 1).

Paleosurface to present-day surface temperatures are important input parameters used by the software to calculate thermal history. We used a module that is included with the PetroMod1D program that calculates paleosurface temperature based on a study by Wrygala (1989). The average annual surface temperature for all the burial history locations in the study area was as follows: 24°C from the time the oldest strata were deposited, decreasing uniformly to 20 ˚C by 200 Ma, then increasing to 24 ˚C by 100 Ma, and decreasing again to 15 ˚C by 33 Ma. Finally, from about 33 Ma the surface temperature cooled gradually to the present average annual surface temperature of 5˚C (Hacquebard, 1977).

The heat flow value, which is also an important input parameter for the PetroMod1D program, is used for the burial history reconstructions (table 2). Present-day heat flow values at the base of the stratigraphic column at each modeled location were determined within the PetroMod1D program by calibrating with the measured downhole temperatures and the present-day and assumed paleosurface temperatures (see above) and the erosion estimate. Although it is probable that heat flow varied through time, it was not necessary to make assumptions about when changes of heat flow occurred or the extent to which heat flow changed through time, because using a constant heat flow through time resulted in an acceptable match of calculated R_o values, as determined by EASY%R_o (Sweeney and Burnham, 1990), with the measured R_o values (fig. 1). The heat flow values calculated for wells 301, 307, 305, and 302 (table 2) are generally consistent with the mapped distribution of basement heat flow in the WCSB (Bachu and Burwash, 1994). The local heat flow anomalies at well locations 306 and 303 could be the result of variable radiogenic heat production in the basement rocks (Bachu and Burwash, 1994; Bachu and Cao, 1992; and Hitchon and others, 1990). Another possible cause for these anomalies, especially at well location 306 (Swan Hills upland), is that heat was being carried along with moving fluids. As the fluids are trapped, so is the heat, creating an anomalous condition at that level, and eventually this condition is transmitted to shallower depths (McGee and others, 1989).

References Cited

Bachu, S., and Burwash, R.A., 1994, Geothermal regime in theWestern Canada Sedimentary Basin, Chapter 30, *in* Mossop, G.D., and Shetson, I., compilers, Geological atlas of the Western Canada Sedimentary Basin: Canadian Society of Petroleum Geologists and Alberta Research Council, Calgary, Alberta, p. 447–454. <http://www.ags.gov.ab.ca/publications/ATLAS_WWW/ATLAS.shtml>, [last accessed 01/18/05].

Bachu, S.B., and Cao, Song, 1992, Present and past geothermal regimes and source rock maturation, Peace River Arch area, Canada: American Association of Petroleum Geologists Bulletin, v. 76, no. 10, p. 1533–1549.

Bloch, J., Schroeder-Adams, Leckie, D. A., McIntyre, D. J., Craig, J., 1999, Sedimentology, micropaleontology, geochemistry, and hydrocarbon potential of shale from the Cretaceous Lower Colorado Group in Western Canada: Geological Survey of Canada Bulletin 531, 185 p.

Bustin, R.M., 1991, Organic maturity in the western Canada sedimentary basin: International Journal of Coal Geology, v. 19, p. 319–358.

Clark, J.P., and Philp, R.P., 1989, Geochemical characterization of evaporite and carbonate depositional environments and correlation of associated crude oils in the Black Creek Basin, Alberta: Bulletin of Canadian Petroleum Geology, v. 37, no. 4, p. 401–416.

Creaney, S., and Allan, J., 1992, Petroleum systems in the foreland basin of Western Canada, *in* Macqueen, R.W., and Leckie, D.A., eds., Foreland basins and fold belts: American Association of Petroleum Geologists Memoir 55, p. 279–308.

Exploration Staff, Chevron Standard Limited, 1979, The geology, geophysics and significance of the Nisku reef discoveries, west Pembina area, Alberta, Canada: Bulletin of Canadian Petroleum Geology, v. 27, no. 3, p. 326–359.

Hacquebard, P.A., 1977, Rank of coal as an index of organic metamorphism for oil and gas in Alberta, *in* Deroo, G., Powell, T.G., Tissot, B., and McCrossan, R.G., eds., The origin and migration of petroleum in the western Canadian sedimentary basin, Alberta; a geochemical and thermal maturation study: Geological Society of Canada Bulletin, v. 262, p. 11–22.

Higley, D.K., Henry, M.E., Roberts, L.N.R., and Steinshouer, D.W., 2005, 1-D/3-D Geologic model of the Western Canada Sedimentary Basin: The Mountain Geologist, v. 42, no. 2, p. 53–66.

Hitchon, Brian, 1984, Geothermal gradients, hydrodynamics, and hydrocarbon generation occurrences, Alberta, Canada: American Association of Petroleum Geologists Bulletin, v. 68, no. 6, p. 713–743.

Hitchon, B., Bachu, S., and Underschultz, J.R., 1990, Regional subsurface hydrogeology, Peace River arch area, Alberta and British Columbia: Bulletin of Canadian Petroleum Geology, v. 38(A), p. 196–217.

IHS Energy Accumap database, 2004, available from IHS Energy, 4100 Dry Creek Road, Littleton, CO 80122.

Issler, D.R., Beaumont, C., Willett, S.D., Donelick, R.A., Mooers, J. and Grist, A., 1991, Preliminary evidence from apatite fission-track data concerning the thermal histoy of the Peace River arch region, Western Canada sedimentary basin: Bulletin of Canadian Petroleum Geology, v. 38A (1990), p. 250–269.

Lexicon of Canadian Stratigraphy, volume 4, Western Canada, 1997, *in* Glass, D.J., ed., Canadian Society of Petroleum Geologists, 1423 p., 1 pdf-format document.

McGee, H.W., Meyer, H.J., and Pringle, T.R., 1989, Shallow geothermal anomalies overyling deeper oil and gas deposits in the Rocky Mountain Region: American Association of Petroleum Geologists Bulletin, v. 73, no. 5, p. 576–597.

Mossop, Grant D. and Shetsen, Irina, 1994, Geological atlas of the Western Canada Sedimentary Basin: Canadian Society of Petroleum Geologists and Alberta Research Council, Calgary, Alberta, <http://www.ags.gov.ab.ca/publications/ATLAS_WWW/ATLAS.shtml>, [last accessed 01/18/05].

Nurkowski, J. R., 1984, Coal quality, coal rank variation and its relation to reconstructing overburden, Upper Cretaceous and Tertiary Plains coals, Alberta, Canada: American Association of Petroleum Geologists Bulletin, v. 68, no. 3, p. 285–295.

Obradovich, J.D., 1991, A revised Cenomanian-Turonian time scale based on studies from the Western Interior United States: Geological Society of America Abstracts with Program, 1991 Annual Meeting San Diego, California, p. A296.

Osadetz, K.G., Jones, F.W., Majorowicz, J.A., Pearson, D.E., Stasiuk, L.E., 1992, Thermal History of the Cordilleran Foreland Basin in Western Canada: A Review: American Association of Petroleum Geologists Memoir 55: Foreland Basins and Fold Belts, Chapter 9, p. 259–278.

Ravenhurst, C.E., Willett, S.D., Donelick, R.A., and Beaumont, C., 1994, Apatite fission track thermochronometry from central Alberta: Implications for the thermal history of the Western Canada sedimentary basin: Journal of Geophysical Research, v. 99, no. B10, p. 20023–20041.

Stasiuk, L.D., and Fowler, M.G., 2002, Thermal maturity evaluation (vitrinite and vitrinite reflectance equivalent) of Middle Devonian, Upper Devonian, and Mississippian strata in the Western Canada Sedimentary Basin: Geological Survey of Canada Open File 4341, 1 CD–ROM.

Stasiuk, L.D., Fowler, M.G., and Addison, G., 2002, Thermal maturity evaluation of Lower Cretaceous Mannville Group and equivalent coals in the Western Canada Sedimentary Basin; a compilation of vitrinite reflectance data: Geological Survey of Canada Open File 4342, 1 CD–ROM.

Sweeney, J.J., and Burnham, A.K., 1990, Evaluation of a simple model of vitrinite reflectance based on chemical kinetics: American Association of Petroleum Geologists Bulletin, v. 74, p. 1559–1570.

Table of Formations of Alberta, (no date), AGAT Laboratories, 3801 21 St NE, Calgary, AB, Canada T2E 6T5. *http://www.agatlabs.com*.

Wrygala, B.P., 1989, Integrated study of an oil field in the southern Po basin, northern Italy: PhD dissertation, University of Koln. Ber. Kernforschungsanlage Juelich 2313, 217 p.

Table 1. Information on wells used for burial history reconstructions in central Alberta, Canada

[KB, Kelly bushing, elevation in meters; TD, Total well depth in meters. Well identification (id) is also location in Alberta Township and Range system: legal subdivision-section-township-range. Well locations shown in fig. 1]

Map no.	Well id	Well name	KB	TD
306	06-36-063-12W5	Imperial Virginia Hills 6-36-63-12	1,130.2	3,264.4
301	16-18-052-5W5	Imperial Cdn-Sup Tomahawk 16-18-52-5	799.8	2,797.1
307	08-22-064-26W4	Trend Royalite Bolloque Lake No. 1	703.8	1,183.5
303	09-13-060-25W4	Petro-Canada Nestow No. 1	620.0	1,143.0
305	15-31-060-20W4	Brook Abee 15-31-60-20	667.5	1,037.5
302	13-03-060-11W4	Canadian Natural Resources Limited Ashmont 13-3-60-11	657.8	1,741.6

Table 2. Data used to generate burial history reconstructions for 6 well locations in central Alberta, Canada.
[Data in first 10 columns starting below 'Sediment Surface' line can be pasted directly into 'input' module of PetroMod1D. Gaps in deposition age are assumed to be periods of nondeposition. Values under 'Generalized lithology' are percentages that PetroMod uses, by default, when records shown in 'Lithology' column are chosen by the user. Gp, Group; U, Upper; L, Lower; ss, sandstone; sh, shale; slts, siltstone; ls, limestone; evap, evaporite; dolo, dolomite; mW/m^2, milliWatts per square meter.
3-D geologic model interval names are from Higley and others (2005). Heat flow and thermal gradient used to calibrate model are given for each location]

06-36-063-12W5 (306)

Name	Top [meter]	Bottom [meter]	Present thickness [meter]	Eroded thickness [meter]	Deposition age from [Ma]	Deposition age to [Ma]	Erosion age from [Ma]	Erosion age to [Ma]	Lithology	Generalized lithology (percent) ss	sh	slts	ls	evap	dolo	3-D gologic model interval names
Sediment Surface			0													
Quaternary	0.0	20.0	20.0		1.6	0.0			SAND&SHALE	50	50					
Paskapoo	20.0	350.0	330.0	750	69.0	58.0	58.0	1.6	SAND&SHALE	50	50					GrColo and erosionf
Wapiti	350.0	989.1	639.1		80.0	70.0			SAND&SHALE	50	50					GrColo
Lea Park	989.1	1076.6	87.5		84.0	80.0			SHALEsilt		70	30				GrColo
U. Colorado Gp (part)	1076.6	1148.0	71.4		86.0	84.0			SHALEsilt		70	30				ColoCard
Badheart	1148.0	1223.0	75.0		88.5	86.0			SANDSTONE	100						ColoCard
Cardium	1223.0	1287.5	64.5		90.0	88.5			SANDSTONE	100						Cardium
2nd White Specks	1287.5	1331.0	43.5		91.5	90.0			SHALEsilt		70	30				2ndWhsp
Dunvegan	1331.0	1460.0	129.0		93.0	91.5			SANDSTONE	100						2ndWhsp
Fish Scale Zone	1460.0	1503.3	43.3		97.5	93.0			SHALE		100					Fishscale
U. Viking	1503.3	1531.6	28.3		100.0	97.5			SAND&SHALE	50	50					Viking
U. Mannville (part)	1531.6	1716.0	184.4		111.0	104.0			SAND&SHALE	50	50					MannvilleU
Glauconitic	1716.0	1734.0	18.0		113.0	111.0			SANDSTONE	100						MannvilleU
L. Mannville	1734.0	1782.5	48.5		119.0	113.0			SAND&SHALE	50	50					MannvilleL
Shunda	1782.5	1802.5	20.0		348.0	345.0			LIMESTONE				100			RundleCha
Pekisko	1802.5	1852.6	50.1		352.0	348.0			LIMESTONE				100			RundleCha
Banff	1852.6	2034.5	181.9		358.0	352.0			SHALE		100					Banff
Exshaw	2034.5	2040.6	6.1		361.0	360.0			SHALE		100					Exshaw
Wabamun	2040.6	2264.7	224.1		366.0	362.0			LIMESTONE				100			Wabamun
Winterburn Gp	2264.7	2480.0	215.3		368.5	366.0			LIMESTONE				100			Wabamun
Woodbend (part)	2480.0	2653.0	173.0		371.0	368.5			LIMEshaly		30		70			Woodbend
Duvernay	2653.0	2713.0	60.0		372.5	371.0			SHALE		100					Woodbend
Beaverhill Lake Gp (part)	2713.0	2777.3	64.3		373.5	372.5			LIMEshaly		30		70			Underburden
Swan Hills reef	2777.3	2859.6	82.3		376.0	373.5			LIMESTONE				100			Underburden
Watt Mtn	2859.6	2870.6	11.0		376.5	376.0			LIMEshaly		30		70			Underburden
Gilwood	2870.6	2879.0	8.4		376.8	376.5			SANDSTONE	100						Underburden
Muskeg	2879.0	2924.0	52.3		378.5	377.0			LIMEsandy	30			70			Underburden
Cambrian (part)	2924.0	3217.2	285.9		538.0	505.0			LIMEsandy	30			70			Underburden
Basal Sandstone	3217.2	3253.0	35.8		540.0	538.0			SANDSTONE	100						Underburden
Precambrian	3253.0	3264.0	11.4		542.1	542			Granite							Underburden

Heat flow 60 mW/m^2 Thermal gradient 29 °C/km

Table 2. Data used to generate burial history reconstructions for 6 well locations in central Alberta, Canada.–Continued

16-18-052-5W5 (301)

Name	Top [meter]	Bottom [meter]	Present thickness [meter]	Eroded thickness [meter]	Deposition age from [Ma]	Deposition age to [Ma]	Erosion age from [Ma]	Erosion age to [Ma]	Lithology	Generalized lithology (percent) ss	sh	slts	ls	evap	dolo	3-D gologic model interval names
Sediment Surface			0													
Quaternary	0.0	40.0	40.0		1.6	0.0			SAND&SHALE	50	50					
Paskapoo-Scollard	40.0	100.0	60.0	1250	69.0	58.0	58	1.6	SAND&SHALE	50	50					GrColo and erosionf
Wapiti	100.0	858.0	758.0		80.0	70.0			SAND&SHALE	50	50					GrColo
Lea Park	858.0	979.0	121.0		84.0	80.0			SHALE&SILT		50	50				GrColo
U. Colorado Gp (part)	979.0	1122.0	143.0		88.5	84.0			SHALE&SILT		50	50				ColoCard
Cardium	1122.0	1165.0	43.0		89.0	88.5			SANDSTONE	100						Cardium
Blackstone	1165.0	1227.0	62.0		90.0	89.0			SHALE&SILT		50	50				Cardium
2nd White Specks	1227.0	1370.4	143.4		95.0	90.0			SHALE&SILT		50	50				2ndWhsp
Fish Scale Zone	1370.4	1407.0	36.6		97.5	95.0			SHALE&SILT		50	50				Fishscale
L. Viking/Jolifou	1407.0	1454.5	47.5		100.0	97.5			SAND&SHALE	50	50					JoliFou and Viking
U. Mannville Gp	1454.5	1620.0	165.5		113.0	104.0			SAND&SHALE	50	50					MannvilleU
L. Mannville Gp (lower)	1620.0	1640.0	20.0		119.0	113.0			SAND&SHALE	50	50					MannvilleL
Nordegg	1640.0	1656.0	16.0		204.0	197.0			LIMESTONE				100			Jurassic
Banff	1656.0	1789.2	133.2		359.0	352.0			SHALE		100					Banff
Exshaw	1789.2	1793.1	3.9		361.0	358.0			SHALE		100					Exshaw
Wabamun	1793.1	1969.0	175.9		366.0	362.0			LIMEshaly		30		70			Wabamun
Winterburn Gp (part)	1969.0	2014.7	45.7		367.5	366.0			LIMESTONE				100			Wabamun
Calmar	2014.7	2023.9	9.2		367.7	367.5			SHALE		100					Wabamun
Nisku	2023.9	2124.5	100.6		368.5	367.7			LIMEshaly		30		70			Wabamun
Woodbend Gp (upper part)	2124.5	2343.0	218.5		371.0	368.5			LIMEshaly		30		70			Woodbend
Woodbend Gp (lower part)	2343.0	2430.8	87.8		372.5	371.0			SHALE		100					Woodbend
Beaverhill Lake	2430.8	2595.4	164.6		376.0	372.5			LIMEshaly		30		70			Underburden
Elk Point Gp (part)	2595.4	2606.0	10.6		376.5	376.0			LIMEshaly		30		70			Underburden
Muskeg	2606.0	2662.0	56.0		378.5	377.0			LIME&EVAP				50	50		Underburden
Keg River	2662.0	2707.0	45.0		381.0	378.5			LIMEdolom				70		30	Underburden
Chinchaga	2707.0	2771.0	64.0		384.0	381.0			EVAPORITE					100		Underburden
Cambrian	2771.0	3100.0	329.0		570.0	508.0			LIMEsandy	30			70			Underburden

Heat flow 47 mW/m^2 Thermal gradient 23 °C/km

Table 2. Data used to generate burial history reconstructions for 6 well locations in central Alberta, Canada.–Continued

08-22-064-26W4 (307)

Name	Top [meter]	Bottom [meter]	Present thickness [meter]	Eroded thickness [meter]	Deposition age from [Ma]	Deposition age to [Ma]	Erosion age from [Ma]	Erosion age to [Ma]	Lithology	Generalized lithology (percent) ss	sh	slts	ls	evap	dolo	3-D gologic model interval names
Sediment Surface			0													
Quaternary	0.0	45.0	45.0		1.6	0.0			SAND&SHALE	50	50					
Cretaceous-Tertiary	45.0	213.4	168.4	850	80.0	59.0	59.0	1.6	SAND&SHALE	50	50					GrColo and erosionf
Lea Park	213.4	356.6	143.2		84.0	80.0			SHALEsilt		70	30				GrColo
U. Colorado Gp	356.6	501.4	144.8		90.0	84.0			SHALEsilt		70	30				ColoCard
2nd White Specks	501.4	601.7	100.3		95.0	90.0			SHALEsilt		70	30				2ndWhsp
Fish Scale Zone	601.7	643.1	41.4		97.5	95.0			SHALE		100					Fishscale
L. Viking	643.1	675.1	32.0		101.0	97.5			SAND&SHALE	50	50					Viking
Blairmore	675.1	850.0	174.9		111.0	104.0			SHALE		100					MannvilleU
Glauconitic	850.0	867.2	17.2		113.0	111.0			SANDSTONE	100						MannvilleU
Ostracod	867.2	876.3	9.1		114.0	113.0			LIMEshaly		30		70			MannvilleL
Ellerslie (Basal Quartz)	876.3	919.0	42.7		119.0	114.0			SAND&SHALE	50	50					MannvilleL
Wabamun	919.0	1047.0	128.0		366.0	362.0			DOLOMITE						100	Wabamun
Winterburn Gp	1047.0	1066.8	19.8		367.5	366.0			LIMESTONE				100			Wabamun
Calmar	1066.8	1089.4	22.6		367.7	367.5			SHALE		100					Wabamun
Nisku	1089.4	1140.9	51.5		368.5	367.7			LIMEshaly		30		70			Wabamun
Ireton	1140.9	1183.5	42.6		371.0	368.5			SHALE		100					Woodbend

Heat flow 48 mW/m^2 Thermal gradient 26 °C/km

Table 2. Data used to generate burial history reconstructions for 6 well locations in central Alberta, Canada.–Continued

09-13-060-25W4 (303)

Name	Top [meter]	0.0 Bottom [meter]	Present thickness [meter]	Eroded thickness [meter]	Deposition age from [Ma]	Deposition age to [Ma]	Erosion age from [Ma]	Erosion age to [Ma]	Lithology	Generalized lithology (percent) ss	sh	slts	ls	evap	dolo	3-D gologic model interval names
Sediment Surface			0													
Quaternary		20.0	20.0		1.6	0.0			SAND&SHALE	50	50					
Cretaceous-Tertiary	20.0	200.0	180.0	900	80.0	58.0	58	1.6	SAND&SHALE	50	50					GrColo and erosionf
Lea Park	200.0	368.8	168.8		84.0	80.0			SHALE&SILT		50	50				GrColo
U. Colorado Gp	368.8	525.8	157.0		90.0	84.0			SHALEsilt		70	30				ColoCard
2nd White Specks	525.8	618.7	92.9		95.0	90.0			SHALEsilt		70	30				2ndWhsp
Fish Scale Zone	618.7	661.4	42.7		97.5	95.0			SHALE		100					Fishscale
Viking/Joli Fou	661.4	699.5	38.1		100.0	97.5			SAND&SHALE	50	50					Viking and JoliFou
Blairmore	699.5	846.0	146.5		111.0	104.0			SHALE		100					MannvilleU
Glauconitic	846.0	873.3	27.3		113.0	111.0			SANDSTONE	100						MannvilleU
Ostracod	873.3	882.4	9.1		114.0	113.0			SAND&SHALE	50	50					MannvilleL
Ellerslie (Basal Quartz)	882.4	963.0	80.6		119.0	114.0			SAND&SHALE	50	50					MannvilleL
Wabamun	963.0	988.0	25.0		366.0	362.0			LIMEshaly		30		70			Wabamun
Winterburn (part)	988.0	1021.1	33.1		367.5	366.0			LIMESTONE				100			Wabamun
Calmar	1021.1	1023.5	2.4		367.7	367.5			SHALE		100					Wabamun
Nisku	1023.5	1095.8	72.3		368.5	367.7			LIMEshaly		30		70			Wabamun
Ireton	1095.8	1111.0	15.2		369.0	368.5			SHALE		100					Woodbend
Leduc Reef	1111.0	1143.0	32.0		370.0	369.0			LIMEshaly		30		70			Woodbend

Heat flow 63 mW/m^2 Thermal gradient 35 °C/km

Table 2. Data used to generate burial history reconstructions for 6 well locations in central Alberta, Canada.–Continued

15-31-060-20W4 (305)

Name	Top [meter]	Bottom [meter]	Present thickness [meter]	Eroded thickness [meter]	Deposition age from [Ma]	Deposition age to [Ma]	Erosion age from [Ma]	Erosion age to [Ma]	Lithology	Generalized lithology (percent) ss	sh	slts	ls	evap	dolo	3-D gologic model interval names
Sediment Surface			0													
Quaternary	0.0	20.0	20.0		1.6	0.0			SAND&SHALE	50	50					
Cretaceous-Tertiary	20.0	251.0	231.0	650	80.0	58.0	58.0	1.6	SAND&SHALE	50	50					GrColo and erosionf
Lea Park	251.0	326.1	75.1		84.0	80.0			SHALEsilt		70	30				GrColo
U. Colorado Gp (part)	326.1	457.2	131.1		90.0	84.0			SHALEsilt		70	30				ColoCard
2nd White Specks	457.2	518.8	61.6		95.0	90.0			SHALEsilt		70	30				2ndWhsp
Fish Scale Zone	518.8	554.7	35.9		97.5	95.0			SHALE		100					Fishscale
Viking	554.7	582.0	27.3		99.5	97.5			SAND&SHALE	50	50					Viking
Joli Fou	582.0	605.0	23.0		100.0	99.5			SHALE		100					JoliFou
Blairmore	605.0	754.0	149.0		111.0	104.0			SHALE		100					MannvilleU
Glauconitic	754.0	765.0	11.0		113.0	111.0			SANDSTONE	100						MannvilleU
L. Mannville (part)	765.0	782.0	17.0		119.0	113.0			SAND&SHALE	50	50					MannvilleL
Wabamum	782.0	793.0	11.0		366.0	362.0			SHALEsilt		70	30				Wabamun
Graminia	793.0	814.0	21.0		367.5	366.0			LIMESTONE				100			Wabamun
Calmar	814.0	829.0	15.0		367.7	367.5			SHALE		100					Wabamun
Nisku	829.0	885.0	56.0		368.5	367.7			LIMEshaly		30		70			Wabamun
Ireton (part)	885.4	1037.5	152.5		371.0	368.5			SAND&SHALE	50	50					Woodbend

Heat flow 47 mW/m^2 Thermal gradient 26 °C/km

Table 2. Data used to generate burial history reconstructions for 6 well locations in central Alberta, Canada.–Continued

13-03-060-11W4 (302)

Name	Top [meter]	Bottom [meter]	Present thickness [meter]	Eroded thickness [meter]	Deposition age from [Ma]	Deposition age to [Ma]	Erosion age from [Ma]	Erosion age to [Ma]	Lithology	Generalized lithology (percent) ss	sh	slts	ls	evap	dolo	3-D gologic model interval names
Sediment Surface			0													
Quaternary	0.0	20.0	20.0		1.6	0.0			SAND&SHALE	50	50					
Late Cretaceous-Tertiary	20.0	187.0	167.0	1400	80.0	58.0	58.0	1.6	SAND&SHALE	50	50					GrColo and erosionf
Lea Park	187.0	254.5	67.5		84.0	80.0			SHALE&SILT		50	50				GrColo
Colorado Gp (part)	254.5	335.0	80.5		90.0	84.0			SHALE&SILT		50	50				ColoCard
2ndWhite Specks	335.0	378.6	43.6		95.0	90.0			SHALE		100					2ndWhsp
Fish Scale Zone	378.6	423.7	45.1		97.5	95.0			SHALE		100					Fishscale
Viking/Joli Fou	423.7	462.7	39.0		101.0	97.5			SAND&SHALE	50	50					Viking and Jolifou
Grand Rapids	462.7	560.0	97.3		108.0	104.0			SAND&SHALE	50	50					MannvilleU
Clearwater	560.0	610.0	50.0		113.0	108.0			SHALE		100					MannvilleU
McMurray	610.0	658.4	48.4		119.0	113.0			SHALEsand	30	70					MannvilleL
Ireton	658.4	685.8	27.4		371.0	368.5			SHALE		100					Woodbend
Duvernay	685.8	766.0	80.2		371.5	371.0			LIMEshaly		30		70			Woodbend
Cooking Lake	766.0	802.2	36.2		373.0	371.5			LIMESTONE				100			Woodbend
Beaverhill Lake Gp (part)	802.2	1019.0	216.8		375.0	373.0			LIMEshaly		30		70			Underburden
Slave point	1019.0	1036.3	17.3		376.0	375.0			LIMEshaly		30		70			Underburden
Watt Mountain	1036.3	1056.1	19.8		376.5	376.0			LIMEshaly		30		70			Underburden
Prairie-Muskeg	1056.1	1197.3	141.2		378.0	377.0			LIME&EVAP				50	50		Underburden
Keg River/Winnipegosis	1197.3	1232.9	35.6		382.0	378.0			LIMEdolom				70		30	Underburden
Contact Rapids/Ashern	1232.9	1283.5	50.6		384.0	382.0			LIMESTONE				100			Underburden
Cold Lake	1283.5	1322.8	39.3		390.0	387.0			EVAPORITE					100		Underburden
Ernestina	1322.8	1341.1	18.3		393.0	390.0			LIMESTONE				100			Underburden
Lotsberg	1341.1	1546.9	205.8		395.0	393.0			EVAPORITE					100		Underburden
Red Beds	1546.9	1565.0	18.1		399.0	395.0			EVAPORITE					100		Underburden
Deadwood	1565.0	1604.8	39.8		523.0	505.0			SHALE		100					Underburden
Earlie	1604.8	1664.2	59.4		536.0	525.0			SHALE&LIME		50		50			Underburden
Basal Sandstone	1664.2	1741.0	76.8		538.0	536.0			SANDSTONE	100						Underburden

Heat flow 51 mW/m^2 Thermal gradient 23 °C/km

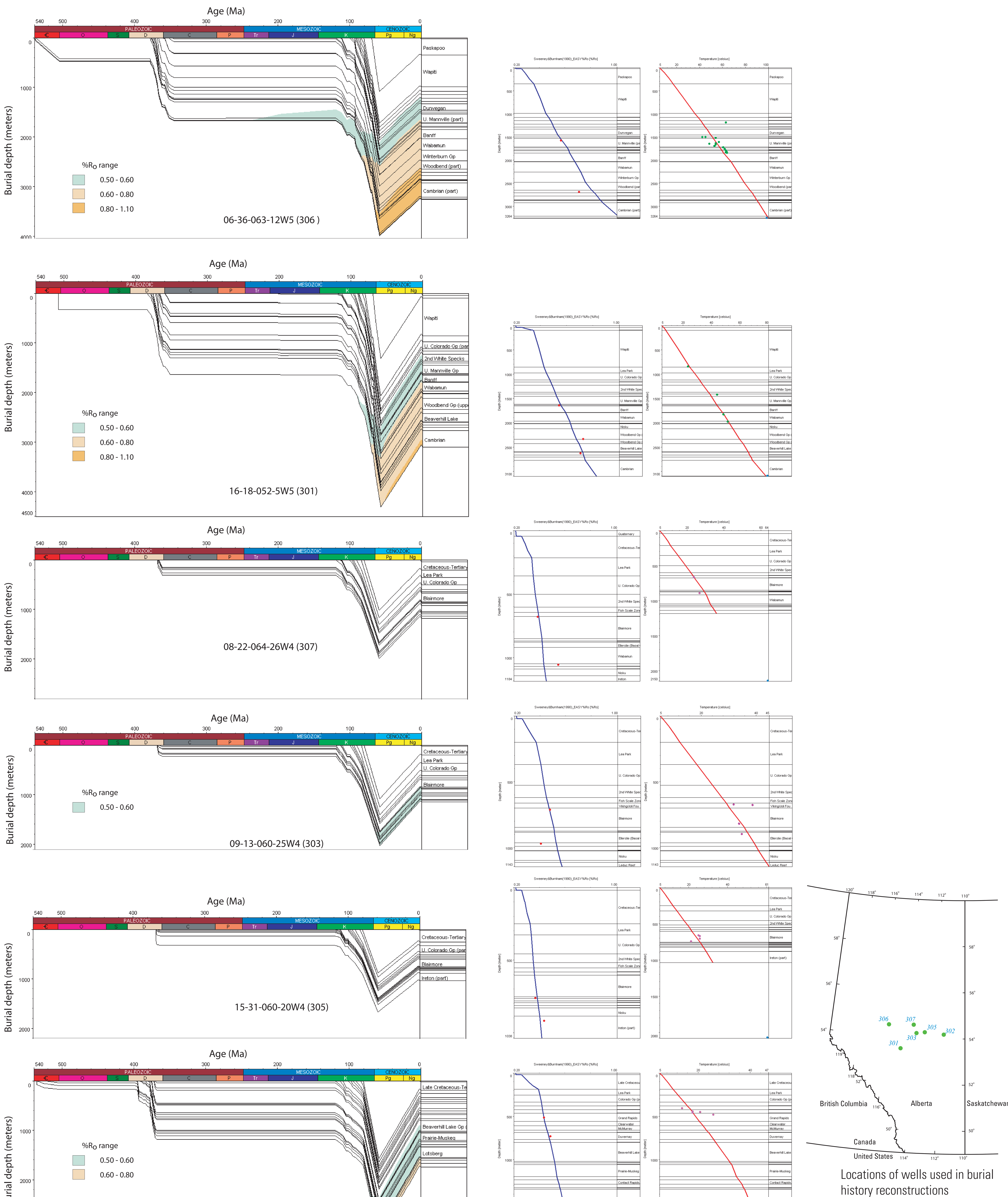

Figure 1. Burial history reconstructions at six well locations in the Western Canada Sedimentary Basin, central Alberta, Canada. Data used to construct the burial history curves are presented in table 2. Measured vitrinite reflectance (%R_0) data (red dots) are from Stasiuk and Fowler (2002) and Stasiuk and others (2002). Kinetic algorithm used is Sweeney and Burnham (1990) Easy%R_0 (blue line). Temperature data are drillstem test values (green dots, purple dots are values from nearby well) and temperature on the Precambrian surface (blue dot) (Bachu and Burwash, 1994).