Geological and Geochemical Data from the Canadian Arctic Islands.

Part III: Organic matter reflectance data.

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Abstract

A total of 6292 organic matter reflectance determinations are given for samples from 140 oil and gas wells (or deviated legs) and 1857 measurements from 346 outcrops or mining drill core from the Arctic Islands. Each sample has a reflectance value, the type of organic matter that was measured and is assigned to a stratigraphic unit. The data is held at the Geological Survey of Canada, but comes from a wide range of sources including GSC files, David Pearson and Associates, Geo-optics Ltd., TeckCominco Ltd., and Panarctic Oils Ltd reports. A depth vs. Ro plot is given for each oil and gas well.

Introduction

The Arctic Archipelago includes a land area of 780,000 km^2 covering much of the Northwest Territories and Nunavut. It contains three of the 10 largest islands in the world (Baffin, Victoria and Ellesmere) plus twenty-two others of appreciable size. There was an oil and gas exploration boom in the Arctic Islands between 1960 and 1985 that resulted in 191 exploration boreholes and the discovery of 20 major petroleum fields. Estimates of the hydrocarbon resource made by the Geological Survey of Canada predict 45 to 50 Tcf of in-place natural gas in the Sverdrup Basin, whereas the National Energy Board (NEB) predicts 45 Tcf of marketable gas in the whole Arctic Islands area.

The Geological Survey of Canada is undertaking an update of the geological and geochemical datasets for the Arctic Islands. This includes organic matter reflectance data (herein), the depth to the top of each stratigraphic unit in the Arctic Islands hydrocarbon exploration boreholes (Dewing and Embry, 2007), and Rock Eval data (Obermajer et al., 2007).

The stratigraphic nomenclature is presented in Figure 1. Formation descriptions are available from the Lexicon of Canadian Geological Names (http://gdr.nrcan.gc.ca/index_e.php). These include age and lithological information, as well as the location of the type section and references. Excellent summaries of the geology of the Canadian Arctic are found in Trettin (1991).

Arctic Islands borehole dataset

This report contains files with organic matter reflectance data for samples from the Arctic Island oil and gas exploration boreholes and from outcrop and mining core. A total of 6292 organic matter reflectance determinations are given for samples from 140 oil and gas wells (or deviated legs) and 1857 measurements from 346 outcrops or mining drill core. These data are archived at GSC-Calgary and include data collected by Panarctic Oils Ltd and stored in the library collections at GSC-Calgary (Leythaeuser and Stewart, 1986), Thomas Gentzis' PhD thesis (Gentzis, 1991), TeckCominco Ltd. samples (Héroux et al., 1999), as well as samples run by the GSC as part of published (e.g., Powell, 1978; Gentzis and Goodarzi, 1993; Goodarzi et al., 1987; 1989) and unpublished regional or stratigraphic studies. The source of data is recorded in source.xls.

In most cases, the GSC no longer has the pellets from which the measurements were made so the reflectance measurements made by external laboratories cannot be verified. The internal consistency of the oil and gas wells data set was checked by comparing the reflectance values between laboratories, and by comparing the Tmax value obtained from RockEval analysis with the reflectance value obtained for vitrinite (Obermajer et al., 2007). This was done by eliminating RockEval samples with low total organic carbon (<0.1%) and with S2<0.35 mg HC/g rock, then converting the Tmax to a vitrinite reflectance equivalent (Ro Vi. eq.%) using the values shown in Table 1 (modified from Peters, 1986; BasinMod1D^{TM}). The conversion was made assuming a Type III organic matter, and the high Tmax values (Tmax>480°C) were partially constrained using data from the Arctic Islands wells since the conversion factor provided by the BasinMod1D software seemed to give corresponding reflectance values that were too high.

There is generally a good correspondance between the reflectance derived by the various labs as well as with the inferred reflectance from the RockEval Tmax parameter. However, a number of wells (e.g., Cape Mamen F-24, Cape Norem A-80, Skybattle M-11) show significant difference between labs, or between the

reflectance determined from vitrinite and the converted RockEval Tmax. No attempt has been made to eliminate caved or reworked samples.

There are two data files: *Ro values from Arctic outcrop.xls* and *Ro values from Arctic Wells.xls*. These files include the following columns:

PELLET_NO – GSC pellet number
BASIN – Franklinian or Sverdrup basins
SAMPLE_NO – GSC-Calgary curation number
LOCATION_NAME – Unique well identifier or sample name
NAD – Datum (1927 or 1983)
LAT – Latitude
LONG – Longitude
FROM (Original) – Top of interval depth in original units, from kelly bushing in wells or from base of section in outcrops
TO (Original) – Base of interval depth in original units, from kelly bushing in wells or from base of section in outcrops
UNITS – Original units (feet or metres)
FROM (m) – Top of interval depth in metres, from kelly bushing in wells or from base of section in outcrops
TO (m) – Base of interval depth in metres, from kelly bushing in wells or from base of section in outcrops
SAMPLE_TYPE – Core, cuttings, outcrop, or unknown.
FORMATION – Stratigraphic unit
RO_TYPE – Organic matter type being measured
RO_VALUE– Average measured reflectance value
RO_N – number of individual readings
RO_SD – standard deviation of reflectance measurements

References

BasinMod1D™

1999: Manual and Software. Platte River Associates.

Dewing, K. and Embry, A.F.

2007: Geological and Geochemical Data from the Canadian Arctic Islands. Part I: Stratigraphic Tops from Arctic Islands Oil and Gas Exploration Boreholes. Geological Survey of Canada Open File 5442, CD-Rom.

Gentzis, T.

1991: Regional maturity and source-rock potential of Paleozoic and Mesozoic strata, Melville Island, Arctic Canada. Unpublished PhD thesis, The Univesity of Newcastle-upon-Tyne.

Gentzis, T., and Goodarzi, F.

1993: Thermal maturity and source-rock potential of the sedimentary succession from the Drake field, Sverdrup Basin, Arctic Canada. Journal of Petroleum Geology, v. 161, p. 33-54.

Goodarzi, F., Brooks, P.W., and Embry, A.F.

1989: Regional maturity as determined by organic petrography and geochemistry of the Schei Point Group (Triassic) in the western Sverdrup Basin, Canadian Arctic Archipelago. Marine and Petroleum Geology, v. 6, p. 290-302.

Goodarzi, F., Nassichuk, W.W., Snowdon, L.R., and Davies, G.R.

1987: Organic petrology and Rockeval analysis of the Lower Carboniferous Emma Fiord Formation in the Sverdrup Basin, Arctic Archipelago. Marine and Petroleum Geology, v. 4, p. 132-145.

Héroux, Y., Chagnon, A., Dewing, K., and Rose, H.R.

1999: The carbonate-hosted base-metal sulphide Polaris deposit in the Canadian Arctic: Organic matter alteration and clay diagenesis. In: M. Glikson and M. Mastalerz (eds). Organic Matter and Mineralisation: Thermal Alteration, Hydrocarbon Generation and Role in Metallogenesis. Kluwer Academic Publisher. p. 260-295.

Leythaeuser, D. and Stewart, K.R.

1986: Generation, migration and accumulation of hydrocarbons in the Sverdrup Basin, Canada. A geochemical basin study. Volume II – tables and figures. Unpublished report to Panarctic Oils. GSC Catalogue No. QE196.9 L4 1986 v.2.

Obermajer, M., Stewart, K.R, and Dewing, K.

2007: Geological and Geochemical Data from the Canadian Arctic Islands. Part II: Rock Eval/TOC data . Geological Survey of Canada Open File 5459, CD-Rom.

Peters, K.E.

1986: Guidelines for evaluating petroleum source rock using programmed pyrolysis. American Association of Petroleum Geologists Bulletin, v. 70, p. 318-320.

Powell, T.G.

1978: An assessment of the hydrocarbon source rock potential of the Canadian Arctic Islands. Geological Survey of Canada, Paper 78-12, 82 p.

Trettin, H.P. (ed.)

1991: Geology of the Innuitian Orogen and Arctic Platform of Canada and Greenland: Geological Survey of Canada, Geology of Canada no. 3 (also Geological Society of America, Geology of North America v. E), 569 p.

Selected References for Figure 1

Beauchamp, B., Harrison, J.C., Utting, J., Brent, T.A., and Pinard, S.

2001: Carboniferous and Permian subsurface stratigraphy, Prince Patrick Island, Northwest Territories, Canadian Arctic; Geological Survey of Canada, Bulletin 565, 93 p.

de Freitas, T., Harrison, J.C., and Mayr, U.

1997: Sequence stratigraphic correlation charts of the lower Paleozoic Franklinian succession, Canadian Arctic and parts of North Greenland. Geological Survey of Canada Open File 3410, 3 charts.

Dewing, K. and Nowlan, G.S.

2004: Correlation chart of Cambrian and Ordovician stratigraphy, Arctic Islands, Nunavut, Canada; Geological Survey of Canada, Open File 1837, 1 chart.

Embry, A.F.

1983a: Stratigraphic subdivision of the Heiberg Formation, eastern and central Sverdrup Basin, Arctic Islands. Geological Survey of Canada, Paper 83-1B, p. 205-213.

1983b: The Heiberg Group, western Sverdrup Basin, Arctic Islands. Geological Survey of Canada, Paper 83-1B, p. 381-389.

1984a: Stratigraphic subdivision of the Roche Point, Hoyle Bay and Barrow formations (Schei Point Group), western Sverdrup Basin, Arctic Islands. Geological Survey of Canada, Paper 84-1B, p. 275-283.

1984b: The Wilkie Point Group (Lower-Upper Jurassic), Sverdrup Basin, Arctic Islands. Geological Survey of Canada, Paper 84-1B, p. 299-308.

1984c: The Schei Point and Blaa Mountain Groups (Middle-Upper Triassic), Sverdup Basin, Canadian Arctic Archipelago. Geological Survey of Canada, Paper 84-1B, p. 327-336.

1985a: Stratigraphic subdivision of the Isachsen and Christopher formations (Lower Cretaceous), Arctic Islands. Geological Survey of Canada, Paper 85-1B, p. 239-246.

1985b: New stratigraphic units, Middle Jurassic to lowermost Cretaceous succession, Arctic Islands. Geological Survey of Canada, Paper 85-1B, p. 269-276.

1986a: Stratigraphic subdivision of the Blind Fiord and Bjorne formations (Lower Triassic), Sverdrup Basin, Arctic Canada. Geological Survey of Canada, Paper 86-1B, p. 329-340.

1986b: Stratigraphic subdivision of the Awingak Formation (Upper Jurassic) and revision of the Hiccles Cove Formation (Middle Jurassic), Sverdrup Basin, Arctic Canada. Geological Survey of Canada, Paper 86-1B, p. 341-349.

1994: Uppermost Triassic, Jurassic, and lowermost Cretaceous stratigraphy, Melville Island area, Arctic Canada. *In*: R.L. Christie and N.J. McMillan (eds.) The Geology of Melville Island, Arctic Canada. Geological Survey of Canada, Bulletin 450, p. 139-159.

Embry, A.F. and Klovan, J.E.

1976: The Middle-Upper Devonian clastic wedge of the Franklinian geosynclin; Bulletin of the Canadian Society of Petroleum Geologists, v. 24, p. 485-639.

Harrison, J.C.

1995: Melville Island's salt-based fold belt, Arctic Canada; Geological Survey of Canada, Bulletin 472, 331 p.

Harrison, J.C. and Brent, T.A.

2005: Basins and fold belts of Prince Patrick Island and adjacent areas, Canadian Arctic Islands; Geological Survey of Canada, Bulletin 560, 197 p.

Mayr, U.

1978: Stratigraphy and correlation of lower Paleozoic formations, subsurface of Cornwallis, Devon, Somerset, and Russell islands, Canadian Arctic Archipelago. Geological Survey of Canada, Bulletin 276, 55 p.

1980: Stratigraphy and correlation of lower Paleozoic formations, subsurface of Bathurst Island and adjacent smaller islands, Canadian Arctic Archipelago. Geological Survey of Canada, Bulletin 306, 52 p.

Mayr, U., Brent, T.A., de Freitas, T., Frisch, T., Nowlan, G.S., and Okulitch, A.V.

2004: Geology of eastern Prince of Wales Island and adjacent smaller islands, Nunavut; Geological Survey of Canada, Bulletin 574, 88 p.

Thorsteinsson, R. and Mayr, U.

1987: The sedimentary rocks of Devon Island, Canadian Arctic Archipelago; Geological Survey of Canada, Memoir 411, 182 p.

Uyeno T.T

1990: Biostratigraphy and conodont faunas of Upper Ordovician though Middle Devonian rocks, eastern Arctic Archipelago. Geological Survey of Canada, Bulletin 401, 210 p.

Table 1. Conversion between Rock-Eval Tmax and equivalent Vitrinite Reflectance (Ro Vi eq %).

Ro Vi eq %	Tmax	Ro Vi eq %	Tmax	Ro Vi eq %	Tmax	Ro Vi eq %	Tmax
0.42	427	1.42	472	1.98	517	2.34	562
0.46	428	1.44	473	1.99	518	2.34	563
0.50	429	1.45	474	2.00	519	2.35	564
0.54	430	1.47	475	2.01	520	2.36	565
0.58	431	1.48	476	2.02	521	2.36	566
0.61	432	1.50	477	2.03	522	2.37	567
0.64	433	1.51	478	2.03	523	2.38	568
0.67	434	1.53	479	2.04	524	2.38	569
0.70	435	1.54	480	2.05	525	2.39	570
0.73	436	1.56	481	2.06	526	2.39	571
0.75	437	1.57	482	2.07	527	2.40	572
0.78	438	1.58	483	2.08	528	2.41	573
0.80	439	1.60	484	2.09	529	2.41	574
0.83	440	1.61	485	2.10	530	2.42	575
0.85	441	1.62	486	2.11	531	2.43	576
0.87	442	1.64	487	2.11	532	2.43	577
0.90	443	1.65	488	2.12	533	2.44	578
0.92	444	1.66	489	2.13	534	2.44	579
0.94	445	1.68	490	2.14	535	2.45	580
0.96	446	1.69	491	2.15	536	2.45	581
0.98	447	1.70	492	2.15	537	2.46	582
1.00	448	1.71	493	2.16	538	2.47	583
1.02	449	1.73	494	2.17	539	2.47	584
1.04	450	1.74	495	2.18	540	2.48	585
1.06	451	1.75	496	2.19	541	2.48	586
1.08	452	1.76	497	2.19	542	2.49	587
1.10	453	1.77	498	2.20	543	2.49	588
1.12	454	1.79	499	2.21	544	2.50	589
1.14	455	1.80	500	2.22	545	2.51	590
1.16	456	1.81	501	2.22	546	2.51	591
1.17	457	1.82	502	2.23	547	2.52	592
1.19	458	1.83	503	2.24	548	2.52	593
1.21	459	1.84	504	2.25	549	2.53	594
1.23	460	1.85	505	2.25	550	2.53	595
1.24	461	1.86	506	2.26	551	2.54	596
1.26	462	1.88	507	2.27	552	2.54	597
1.28	463	1.89	508	2.28	553	2.55	598
1.30	464	1.90	509	2.28	554	2.55	599
1.31	465	1.91	510	2.29	555	2.56	600
1.33	466	1.92	511	2.30	556	2.56	601
1.34	467	1.93	512	2.30	557	2.57	602
1.36	468	1.94	513	2.31	558	2.57	603
1.38	469	1.95	514	2.32	559	2.58	604
1.39	470	1.96	515	2.32	560	2.58	605
1.41	471	1.97	516	2.33	561	2.59	606