

Petroleum source rocks in East Greenland: implications for exploration of the Jan Mayen Microcontinent

Jørgen A. Bojesen-Koefoed

Geological Survey of Denmark and Greenland (GEUS)
Øster Voldgade 10
DK-1350K Copenhagen
<http://www.geus.dk>

The Upper Palaeozoic – Mesozoic succession in central East Greenland is the most important outcrop analog to understand the stratigraphy and hydrocarbon potential of the offshore basins on the North-East Greenland shelf and other areas in the North Atlantic, including the Norwegian and Barents shelves, areas near the Faroe Islands, and the offshore areas of the Jan Mayen Microcontinent, in particular the Jan Mayen Basin west of the Jan Mayen Ridge.

In East and Northeast Greenland, post-Caledonian sediments are exposed from Jameson Land to the south to Store Koldewey to the north. The exposed Devonian–Cretaceous sedimentary succession has a composite thickness of more than 10 kilometres, and seismic data indicate thicknesses in excess of 15 kilometres in the Jameson Land basin

Within the sedimentary succession exposed onshore East and Northeast Greenland, organic-rich sediments with petroleum source potential have been identified in a number of different stratigraphic levels ranging in age from the Middle Devonian to the Jurassic (?Cretaceous). The potential source rocks include both lacustrine and marine deposits with highly variable characteristics and regional distribution.

It is generally accepted that the Jan Mayen Microcontinent represents a “slice” of the East Greenland shelf that due the shifting of the Atlantic rifting axis from the Aegir Ridge to the Kolbeinsey Ridge separated from East Greenland just prior to magnetic anomaly 6, i. e. approximately 20 million years ago. Geophysical data collected across the southern part of the Jan Mayen Microcontinent suggest the presence of continental crust overlain by rather thick successions of Palaeozoic, Mesozoic and Cenozoic sedimentary rocks as well as local occurrences of volcanics. Hence, some or all of the petroleum source rock units known from East Greenland can be expected to be present within the sedimentary fill of the Jan Mayen Basin.

This presentation summarises the present knowledge on stratigraphy, distribution, quality and geochemical characteristics of eight stratigraphic intervals having petroleum source potential in East and Northeast Greenland, and presents an assessment of their potential presence and quality in the Jan Mayen Basin.

Literature, petroleum geology, Northeast Greenland

1. Bojesen-Koefoed, J. A., Christiansen, F. G., Petersen, H. I. Piasecki, S., Stemmerik, L. & Nytoft, H.P. 1996: Resinite-rich coals of Northeast Greenland - a hitherto unrecognized, highly oil-prone Jurassic source rock. *Bulletin of Canadian Petroleum Geology*, 44, 458–473.
2. Bojesen-Koefoed, J. A., Petersen, H. I., Surlyk, F. and Vosgerau, H. 1997: Organic petrography and geochemistry of inertinite-rich mudstones, Jacobsstigen Formation, Upper Jurassic, Northeast Greenland: indications of forest fires and variations in relative sealevel. *International Journal of Coal Petrography* 34, 345-370
3. Christiansen, F. G., Dam, G., Piasecki, S. & Stemmerik, L. 1992: A review of Upper Palaeozoic and Mesozoic source rocks from onshore East Greenland. *In: Generation, accumulation and production of Europe's hydrocarbons II*, Spencer, A. M. (ed.), Special Publication of the European Association of Petroleum Geologists 2, 151–161.
4. Christiansen, F. G., Gautier, D. L., Stemmerik, L., Bidstrup, T., Bojesen-Koefoed, J. A. & Sørensen, K. 2006: Petroleum Resource Potential of the East Greenland Shelf. Extended Abstract, Poster. *AAPG Hedberg Research Conference on Understanding World Oil Resources*, November 12-17, 2006 – Colorado Springs, Colorado, USA.
5. Christiansen, F. G., Larsen, H. C., Marcussen, C., Piasecki, S. & Stemmerik, L. 1993: Late Paleozoic plays in East Greenland. *In Parker, J. R. (edit.) Petroleum geology of Northwest Europe, Proceedings of the 4th Conference.* The Geological Society of London, 657-666.
6. Christiansen, F. G., Olsen, H., Piasecki, S. & Stemmerik, L. 1990: Organic geochemistry of Upper Palaeozoic lacustrine shales in the East Greenland basin. *Organic Geochemistry* 16, 287–294.
7. Christiansen, F.G., Piasecki, S., Stemmerik, L. & Telnæs, N. 1993: Depositional environment and organic geochemistry of the Upper Permian Ravnefjeld Formation source rock in East Greenland. *American Association of Petroleum Geologists Bulletin* 77, 1519–1537.

8. Dam, G. & Christiansen, F. G., 1990. Organic geochemistry and source potential of the lacustrine shales of the Upper Triassic – Lower Jurassic Kap Stewart Formation, East Greenland. *Marine and Petroleum Geology* 7, 428–443
9. Dam, G. & Surlyk, F. 1992: Forced regressions in a large wave and storm-dominated lake, Rhaetian–Sinemurian Kap Stewart Formation, East Greenland. *Geology* 20, 749–752.
10. Dam, G. & Surlyk, F. 1993: Cyclic sedimentation in a large wave and storm-dominated anoxic lake: Kap Stewart Formation (Rhaetian–Sinemurian), Jameson Land, East Greenland. In: Posamentier, H. W., Summerhayes, C. P., Haq, B. U. & Allen, G. P. (eds.): *Sequence Stratigraphy and Facies Associations*, IAS Spec. Publ. 18, 419–448.
11. Dam, G., Surlyk, F., Mathiesen, A. & Christiansen, F. G. 1994: Exploration significance of lacustrine forced regressions of the Rhaetian-Sinemurian Kap Stewart Formation, Jameson Land, East Greenland. In Steel, R. J. *et al.* (edit.) *Sequence stratigraphy: Advances and Application for Exploration and Producing in North West Europe*. Norwegian Petroleum Society, Elsevier, Amsterdam, 509-525.
12. Gautier, D.L. 2007: Assessment of undiscovered oil and gas resources of the East Greenland Rift Basin Province. U.S. Geological Survey Fact *Sheet* **2007-3077**, 4 p.
13. Hamann, N E., Whittaker, R. C. & Stemmerik, L. 2005: Geological development of the Northeast Greenland Shelf. In Dore, A. G. & Vining, B. A. (eds), *Petroleum Geology: North-West Europe and Global Perspectives*. Proceedings of the 6th Petroleum Geology Conference, 887-902
14. Ineson, J. & Surlyk, F. (eds.) 2003: The Jurassic of Denmark and Greenland. Geological Survey of Denmark and Greenland Bulletin **1**, 948 pp.
15. Koppelhus, E. B. & Hansen, C. F. 2003: Palynostratigraphy and palaeoenvironment of the Middle Jurassic Sortehat Formation (Neill Klint Group). Jameson Land East Greenland. In: Ineson, J, R. and Surlyk F. (eds.): *The Jurassic of Denmark and Greenland*. Geological Survey of Denmark and Greenland Bulletin 1, 777–811
16. Krabbe, H. 1996: Biomarker distribution in the lacustrine shales of the Upper Triassic – Lower Jurassic Kap Stewart Formation, Jameson Land, Greenland. *Marine and Petroleum Geology* 13, 741–754.

17. Krabbe, H., Christiansen, F.G., Dam, G., Piasecki, S. & Stemmerik, L. 1994: Organic geochemistry of the Lower Jurassic Sortehat Member, Jameson Land, East Greenland. Rapport Grønlands Geologiske Undersøgelse 164, 5–18.
18. Larsen, H. C, 1984: Geology of the East Greenland shelf. *In* Spencer, A. M. *et al.* (eds) Petroleum Geology of the North European Margin. Norwegian Petroleum Society, 329-339.
19. Larsen, H. C. 1990: The East Greenland shelf. *In* Grant, A. *et al.* (eds) The Arctic Ocean Region. Boulder, Colorado. Geological Society of America. The geology of North America **L**, 185-210.
20. Mathiesen, A., Christiansen, F. G., Bidstrup, T., Dam, G., Marcussen, C., Piasecki, S. & Stemmerik, L. 1995: Modelling of hydrocarbon generation in the Jameson Land basin, East Greenland. *First Break* **13**, 329-341.
21. Nøhr-Hansen, H. 1993b: Dinoflagellate cyst stratigraphy of the Barremian to Albian, Lower Cretaceous, East Greenland. Bulletin Grønlands Geologiske Undersøgelse 166, 171 pp.
22. Nøhr-Hansen, H & Piasecki, S. 2002: Palaeocene age of sub-basaltic sediments at Savoia Halvø, East Greenland. Geology of Greenland Survey Bulletin 191 111-116.
23. Olsen, H. 1993: Sedimentary basin analysis of the continental Devonian basin in North-East Greenland. Bulletin Grønlands Geologiske Undersøgelse 168, 80 pp.
24. Olsen, H. & Larsen, P.-H. 1993: Lithostratigraphy of the continental Devonian sediments in North-East Greenland. Bulletin Grønlands Geologiske Undersøgelse 165, 108 pp.
25. Petersen, H. I., Bojesen-Koefoed, J. A., Nytoft, H. P., Surlyk, F., Therkelsen, J. & Vosgerau, H., 1998: Relative sea-level changes recorded by paralic liptinite-enriched coal facies cycles, Middle Jurassic Muslingebjerg Formation, Hochstetter Forland, Northeast Greenland. International Journal of Coal Geology 35, 1–29.
26. Petersen, H. I., Bojesen-Koefoed, J. A. & Nytoft, H. P. 2002: Source rock evaluation of Middle Jurassic coals, Northeast Greenland, by artificial maturation: aspects of petroleum generation from coal. American Association of Petroleum Geologists Bulletin 86, 233–256.

27. Petersen, H.I. & Vosgerau, H., 1999: Composition and organic maturity of Middle Jurassic coals, North-East Greenland: evidence for liptinite-induced suppression of huminite reflectance. *International Journal of Coal Geology* 41, 257–274.
28. Piasecki, S. & Stemmerik, L. 1991: Late Permian anoxia of central East Greenland. In: *Modern and ancient shelf anoxia*, Tyson, R. V. & Pearson, T. H. (eds.): Geological Society London Special Publication 58, 275–290.
29. Piasecki, S., Christiansen, F. G. & Stemmerik, L. 1990: Depositional history of a Late Carboniferous organic-rich shale from East Greenland. *Bulletin of Canadian Petroleum Geology* 38, 273–287.
30. Price, S. P. & Whitham, A. G. 1997: Exhumed hydrocarbon traps in East Greenland: analogs for the Lower-Middle Jurassic play of Northwest Europe. *American Association of Petroleum Geologists Bulletin*, 81, 196-221.
31. Requejo, A. G., Hollywood, J., & Halpern, H. I., 1989: Recognition and source correlation of migrated hydrocarbons in Upper Jurassic Hareelv Formation, Jameson Land, East Greenland. *American Association of Petroleum Geologists Bulletin* 73, 1065–1088.
32. Scott, R. A. & Whitham, A. G. 2000: East Greenland geology plays role in Northwest European margin. Re-interpreting the continent-ocean boundary. *Offshore*, Sept. 2000, 148, 150, 184
33. Stemmerik, L., 2001: Sequence stratigraphy of a low productivity carbonate platform succession: the Upper Permian Wegener Halvø Formation, Karstryggen area, East Greenland. *Sedimentology* 48, 79–97.
34. Stemmerik, L., Christiansen, F. G. & Piasecki, S. 1990: Carboniferous lacustrine shale in East Greenland - additional source rock in the northern North Atlantic? In: Katz, B. J., (ed.): *Lacustrine basin exploration - case studies and modern analogs*, American Association of Petroleum Geologists Memoir 50, 277–286.
35. Stemmerik, L., Christiansen, F. G., Piasecki, S., Andersen, B. E., Marcussen, C. & Nøhr-Hansen, H., 1993: Depositional history and petroleum geology of the northern part of the East Greenland basin. In Vorren, T. O. et al. (edit.) *Arctic Geology and Petroleum Potential*. Norwegian Petroleum Society, Elsevier, 67-87.
36. Stemmerik, L. & Stouge, S. (eds.) 2004: The Jurassic of North-East Greenland. *Geological Survey of Denmark and Greenland Bulletin* 5, 112 pp.

37. Strogon, D. P., Burwood, R. & Whitham, A. G., 2005: Sedimentology and geochemistry of Late Jurassic organic-rich shelfal mudstones from East Greenland: regional and stratigraphic variations in source rock quality. In: Doré, A. G. & Vining, B. A. (eds.): *Petroleum Geology: Northwest Europe and Global Perspectives – Proceedings of the 6th Petroleum Geology Conference*. Geol. Soc. London. 903–912.
38. Surlyk, F. 1987: Slope and deep shelf gully sandstones, Upper Jurassic, East Greenland. *American Association of Petroleum Geologists Bulletin* 71, 464–475.
39. Surlyk, F. 1990: Timing, style and sedimentary evolution of Late Palaeozoic – Mesozoic extensional basins of East Greenland. In: Hardman, R. F. P. & Brooks, J. (eds) *Tectonic events responsible for Britain's oil and gas reserves*. Geological Society, Special Publ. **55**, 107-155.
40. Surlyk, F. 1991: Sequence stratigraphy of the Jurassic–lowermost Cretaceous of East Greenland. *AAPG* **75**(9), p. 1468–1488.
41. Surlyk, F. 2003: The Jurassic of East Greenland: a sedimentary record of thermal subsidence, onset and culmination of rifting. In: Ineson, J. R. and Surlyk F. (eds.): *The Jurassic of Denmark and Greenland*. Geological Survey of Denmark and Greenland Bulletin 1, 659–722.
42. Surlyk, F. & Noe-Nygaard, N. 2001: Sand remobilisation and intrusion in the Upper Jurassic Hareelv Formation of East Greenland. In: Surlyk, F. & Håkansson, E. (eds.): *The "Oscar Volume"*, Bulletin of the Geological Society of Denmark 48, 169–188.
43. Surlyk, F. & Noe-Nygaard, N. 2003: A Giant Sand Injection Complex: The Upper Jurassic Hareelv Formation of East Greenland. *Geologia Croatica* **56**(1), 69-81.
44. Surlyk, F. & Noe-Nygaard, N. 2005: A forced regressive shelf-margin wedge formed by transition-slope progradation: lowermost Cretaceous Rauk Plateau Member, Jameson Land, East Greenland. In: Håkansson, E. & Surlyk, F. (eds.): *Walther Volume*. Bulletin of the Geological Society of Denmark. p. 227–243.
45. Surlyk, F., Gjelberg, J. & Noe-Nygaard, N. 2007: The Upper Jurassic Hareelv Formation of East Greenland: A giant sedimentary injection complex. In: Hurst, A. & Cartwright, J. (eds.): *Sand injectites: Implications for hydrocarbon exploration and production*. AAPG Memoir **87**, p. 141–149.
46. Surlyk, F., Hurst, J. M., Piasecki, S., Rolle, F., Scholle, P. A., Stemmerik, L. & Thomsen, E. 1986: The Permian of the western margin of the Greenland Sea - a future exploration target. In: Halbouty, M. T. (ed.): *Future petroleum*

provinces of the world, American Association of Petroleum Geologists Memoir 40, 629–659.

47. Tsikalas, F., Faleide, J. I., Eldholm, O. & Wilson, J. 2005: Late Mesozoic-Cenozoic structural and stratigraphic correlations between the conjugate mid-Norway and NE Greenland continental margins. *In* Dore, A. G. & Vining, B. A. (eds), *Petroleum Geology: North-West Europe and Global Perspectives. Proceedings of the 6th Petroleum Geology Conference*, 887-902
48. Vosgerau, H., Bojesen-Koefoed, J. A., Petersen, H. I. and Surlyk, F. 2000: Forest fires, climate and sealevel changes in a coastal plain-shallow marine succession (Early–Middle Oxfordian Jacobsstigen Formation Northeast Greenland). *Journal of Sedimentary Research* 70, 408-418
49. Voss, M. & Jokat, W. 2007: Continent-ocean transition and voluminous magmatic underplating derived from P-wave velocity modeling of the East Greenland continental margin. *Geophys. J. Int.*