DID THE MJØLNIR ASTEROID IMPACT IGNITE THE BARENTS SEA HYDROCARBON SOURCE ROCKS? H.Dypvik[1], W.S.Wolbach[2], V.Shuvalov[3] and S.L.W.Weaver[4], [1] Department of Geosciences, University of Oslo, Oslo, Norway (henning.dypvik@geo.uio.no), [2] Department of Chemistry, DePaul University, Chicago, Illinois, USA (wwolbach@condor.depaul.edu), [3] Institute of Geosphere Dynamics, Russian Academy of Sciences, Moscow, Russia (shuvalov@idg.chph.ras.ru), [4]Department of Chemistry, California Institute of Technology, Pasadena, California, USA (swidicus@caltech.edu)

Background: The late Jurassic sedimentation in the paleoBarents Sea was dominated by hypoxic deposition of organic rich clays in wide areas [1]. These dark grey shales, the Hekkingen Formation, currently have an average thickness of about maximum 150 m, with an average of 8 % TOC, kerogen type II,. The shales form the major hydrocarbon source rock in the Barents Sea [1-2].

The Mjølnir impact crater was formed in the late Jurassic (142 ± 2.6 Ma) by the impact of a 1.5 km large asteroid into this about 400 m deep sea (Fig.1) [3-4]. During this encounter the crater was formed, ejecta widely spread and tsunami generated [5-6]. Simulations indicate that normal sea level was reestablished in the crater after a sub aerial exposure of about 20 minutes [5].

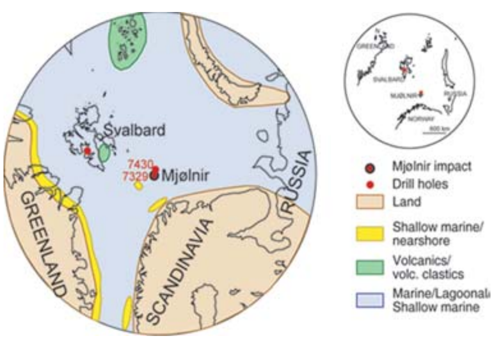

Figure 1. Recent map and paleogeographic setting (150 Ma, Kimmeridgian, absolute frame) of the studied region. Two shallow cores from the Barents Sea (7430 and 7329) and a section on Svalbard are marked by red dots.

Methods: We analyzed samples from cores (7430/10-U-01 and 7329/03-U-01) and surface sections on Svalbard (500 km west of the crater (Fig.1). Lightly mortared samples were dissolved in HCl and HF and treated by acidic dichromate oxidation solution. Elemental carbon of interest (aciniform soot) was identified and characterized using SEM analysis [7] (Fig. 2, Table 1). Numerical simulations of the impact were performed according to the SOVA multi-material hydrocode [8]. The flight and ultimate deposition of the ejecta have been calculated using ballistic approximation [6]. The input parameters were an 800 m in radius granite bolide, a 45^o oblique impact from southwest at 20 km/s, calcite target area and a 400 m deep paleo-Barents Sea. Ignition temperatures used in the calculations are 673 K and 443 K [9], a temperature span covering the pyrolysis of type II/III kerogen and resulting in a conservative value for soot production.

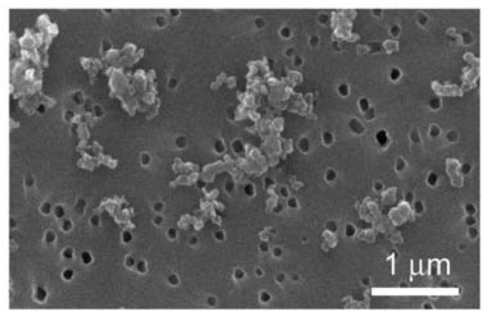

Figure 2.SEM micrograph of aciniform soot in sample 36.7 from Svalbard. The soot particles are mounted on a Nuclepore polycarbonate filter.

Results: Twelve samples from the 7329-core were analyzed for soot, but only three samples contained measurable amounts (Table 1), in much lower concentrations than found in the 7430 core and on Svalbard (Table 1). In the core 7430 samples several high soot concentrations were found in the uppermost part of the Hekkingen Formation (Table 1). The highest enrichment in sample 46.79 (32000 ppm) accompanied by enrichments of Ir, V, Cr and Ni and shocked quartz [10]. The Svalbard samples display fairly high concentrations and sample 36.7 contains 5800 ppm (Table 1), about 3-4 m above an iridium enriched sample and samples with possible Ni-rich iron oxides [11-12].

In the 3D numerical experiments, soot was found to reach heights of 28 km after about 5 seconds, with the oblique Mjølnir impact

Svalbard		Core 7430		Core 7329	
Sample number	ppm soot	Sample number	ppm soot	Sample number	ppm soot
37,54	<2	45,09	8800	62,27	66
36,7	5800	45,73	4800	64,93	310
35,3	<3	46,15	3400	71,1	<5
34,32	<2	46,57	<5	73,72	<11
33,7	<1	46,79	32000	75,43	<3
33,5	<3	47,4	<4	75,68	<2
32,6	39	47,52	460	79,27	<7
30,9	990	47,8	16000	85,48	<4
33,9	<3	48,85	3700	87,93	100
33,3	9	53,5	<4	101,05	<3
33,55	5	62,8	540	115,09	<3
33,75	520			152	<4
34	<4				

Table 1. The soot distribution in three sections, the two Barents Sea cores (7430 and 7329) and the section from Svalbard .

explaining the asymmetrical ejecta distribution (Fig.3) [6]. In our simulations (2D and 3D) temperature calculations have shown that a circular area of 6-8 km in diameter was heated by impact shock above pyrolysis temperature. According to the simulations (3D), within 10s, 2 $*10^{13}$kg (443K) or 1.3 $*10^{13}$ kg (673K) was heated above the indicated temperatures.

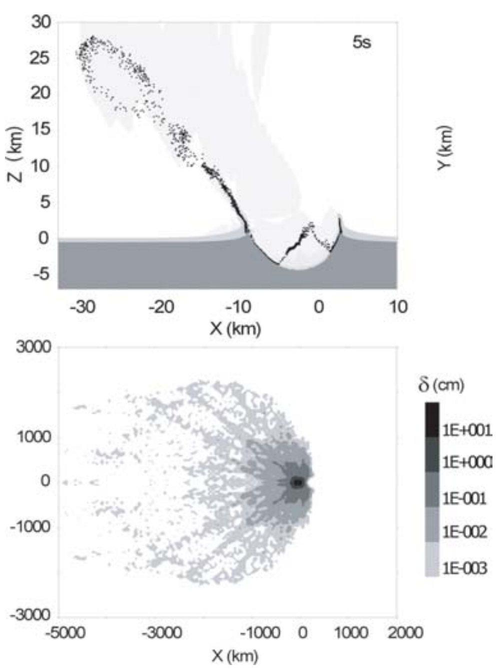

Figure 3. The numerical simulation of the ejecta distribution of a 100 m upper layer which reached a temperature above 443 K. During this oblique impact an asymmetrical distribution is clearly developed towards the North [6].

Conclusion: The soot formation took place just after impact and most likely had an initial distribution similar to that of other accompanying ejecta. At the time of impact the paleogeographic position of the impact site was hundreds of km from the closest forest, making wildfires on surrounding land not very probable. We find it more likely that the soot particles came from pyrolysis and combustion heating of the organic rich, partly volatile, dark clays of the sea bed (Hekkingen Formation). This heating occurred during shock wave propagation through the target sediments (1-2 seconds), with fire lasting the 20 minutes dry sea bed period, before pre-impact sea level returned [5].

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References:

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