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Understanding and predicting the environmental impact

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In-situ burning of crude oil in the Arctic

Understanding and predicting the environmental impact

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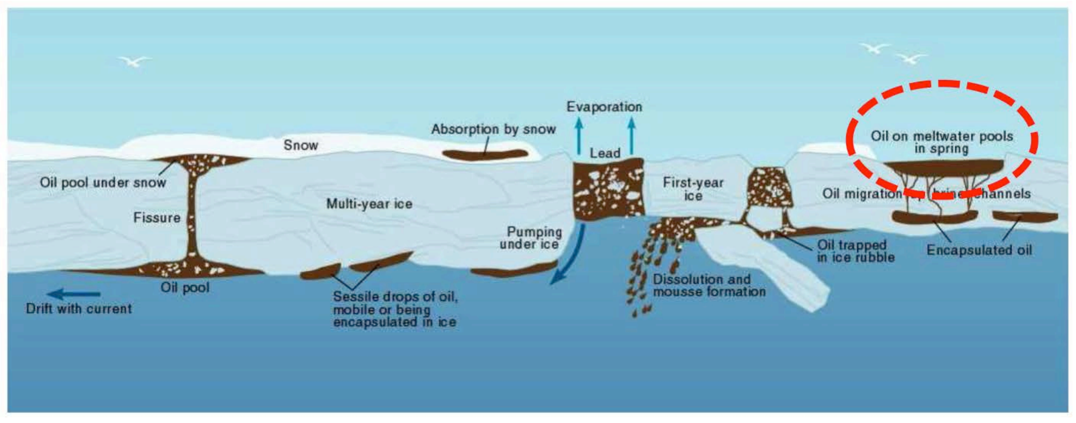
Background

Oil spills are the main threat to the Arctic environment and with the expected increase of e.g. naval and oil drilling activities, accidents become increasingly more likely. Due to the special conditions featured in the Arctic, *in-situ* burning is in many situations the most effective cleaning method. The technique has shown high burning efficiencies of over 90% and is easily deployable in icy waters.[1] However, few studies have been conducted on the influence of ice on the ignition and burning behavior of oils and the resulting impact on the Arctic environment. In this Ph.D. study the focus lies on determining and minimizing the environmental impact *in-situ* burning can have, based on a mechanistic understanding of the burning process.



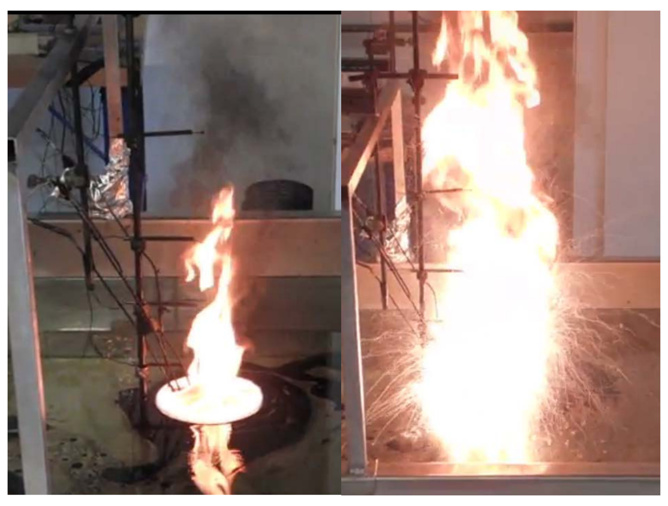
Different type of ice/oil interactions. The target area of this study is highlighted in the red oval[2]

Mechanistic studies

Boilover

Boilovers are well-known phenomena in laboratory setups, but are not seen during *in-situ* burnings on sea.[1] Due to the ocean current, the water below the oil would be refreshed too quickly to heat up. Determine boilover possibilities for:

- Sea currents
- Still waters



Left: regular burning. Right: boilover. Conducted with the new COFA setup[3]

Burn efficiency

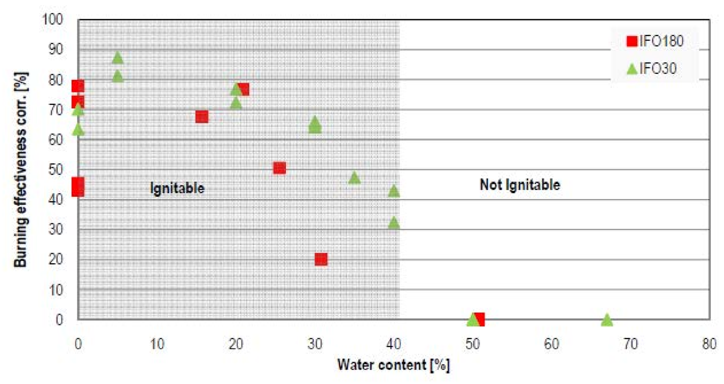
Optimization in terms of:

- Oil composition
- Layer thickness
- Spill diameter
- Ambient conditions

Window of opportunity

In-situ burning can only be used within a certain time frame after an oil spill, known as the window of opportunity. This is determined by:

- Oil evaporation
- Weathering[4]



Ignitability of the oil in relation to water mixing[4]

Ice influence

How does ice influence the burning mechanics?

- Boil over
- Burn efficiency
- Window of opportunity

Oil in ice-covered water[4]

Environmental impact

Toxicity

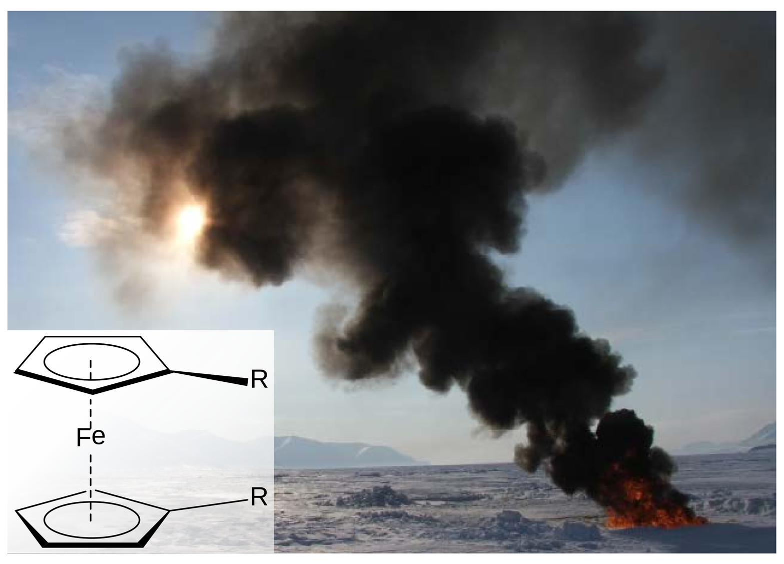
The toxicity of the combustion products from *in-situ* burning is a very important aspect of this technique. Especially the relative toxic impact (Δ_{tox}), compared to an unhandled oil spill or other response methods, determines whether or not *in-situ* burning is a favorable response method. The main toxicity areas concern the:

- Sub surface
- Surface
- Sea bottom
- Airborne
- Long-term studies
- Dilution
- Chemical enhancers

Smoke and soot

One of the biggest concerns related to the environmental impact of *in-situ* burning is the large amount of black smoke that is formed during the process. The black color is caused by soot originating from incomplete combustion of the oil. Smoke formation can be reduced via:

- Mechanistic optimization
- Chemical additives (e.g. ferrocene)[5]

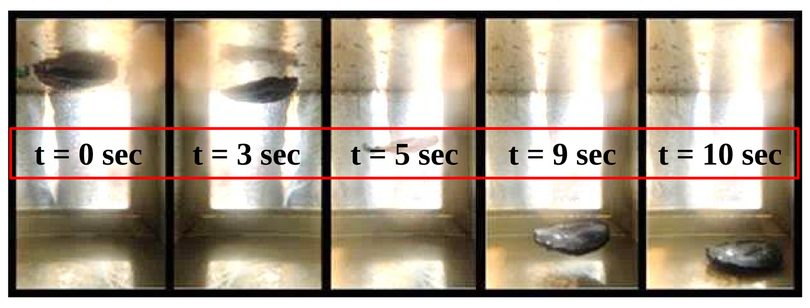


Smoke formation during *in-situ* burning[4] which can be reduced by chemical additives

Residue

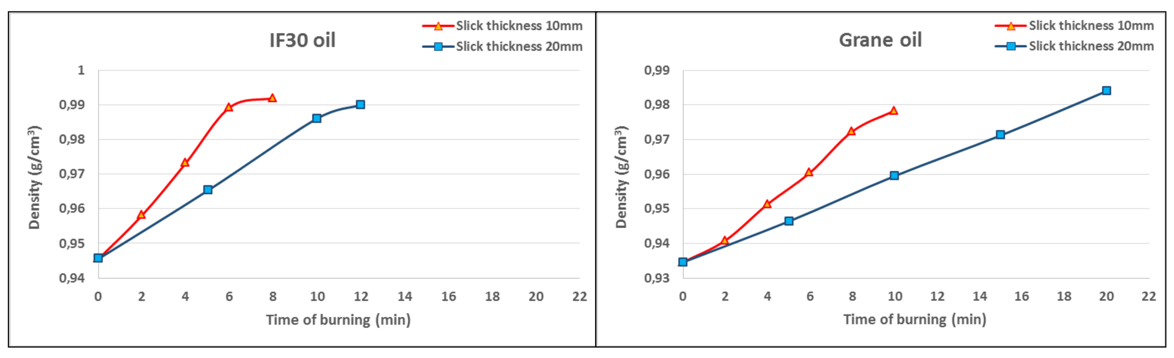
After the *in-situ* burning of a crude oil a residue will be left behind. Depending on the burn efficiency, the residue can vary from a thin liquid layer to a thick solid-like layer. Under certain conditions, the density of the residue can increase upon cooling even to the point where it becomes heavier than water and sinks.[6] This phenomenon creates a potential time constraint for the cleaning of the residue. Hence more knowledge about the sinking of residues is required and a quick and effective cleaning method should be developed. Thus the main topics regarding the residue are:

- Window of opportunity for cleaning
- More efficient cleaning methods



After cooling, the formed residue can possibly sink in a short time window, blocking cleaning options[3]

Manual cleaning of oil. Effective but unpractical (Photo: P. J. Brandvik)



During the burning the density of the oil gradually increases which can result in residues heavier than water

Sociopolitical aspects

While *in-situ* burning has been successfully applied during a number of oil spills over the past decennia and the technique is seen as the best response method for oil spills by many scientists, it is not commonly seen on political agendas.[7] In general, *in-situ* burning seems to have a bad reputation amongst decision-makers and the public. Environmental uncertainties will have to be solved before acceptance can be gained, such as:

- Toxicity of combustion products
- Smoke formation
- Cleaning of the residue

The goal

To develop a simple, *applicable* procedure for *in-situ* burning of crude oil under Arctic conditions.

This goal is to be reached in three distinctive steps:

- Understand the mechanisms of *in-situ* burning under Arctic conditions
- Understand and be able to predict the environmental impact on the Arctic
- Adept to the demands and concerns of decision-makers and the public

Contact

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