



FisherMan



Petroleum Production in Symbiosis with Fisheries?

Torleiv Bilstad and Evgenia Protasova



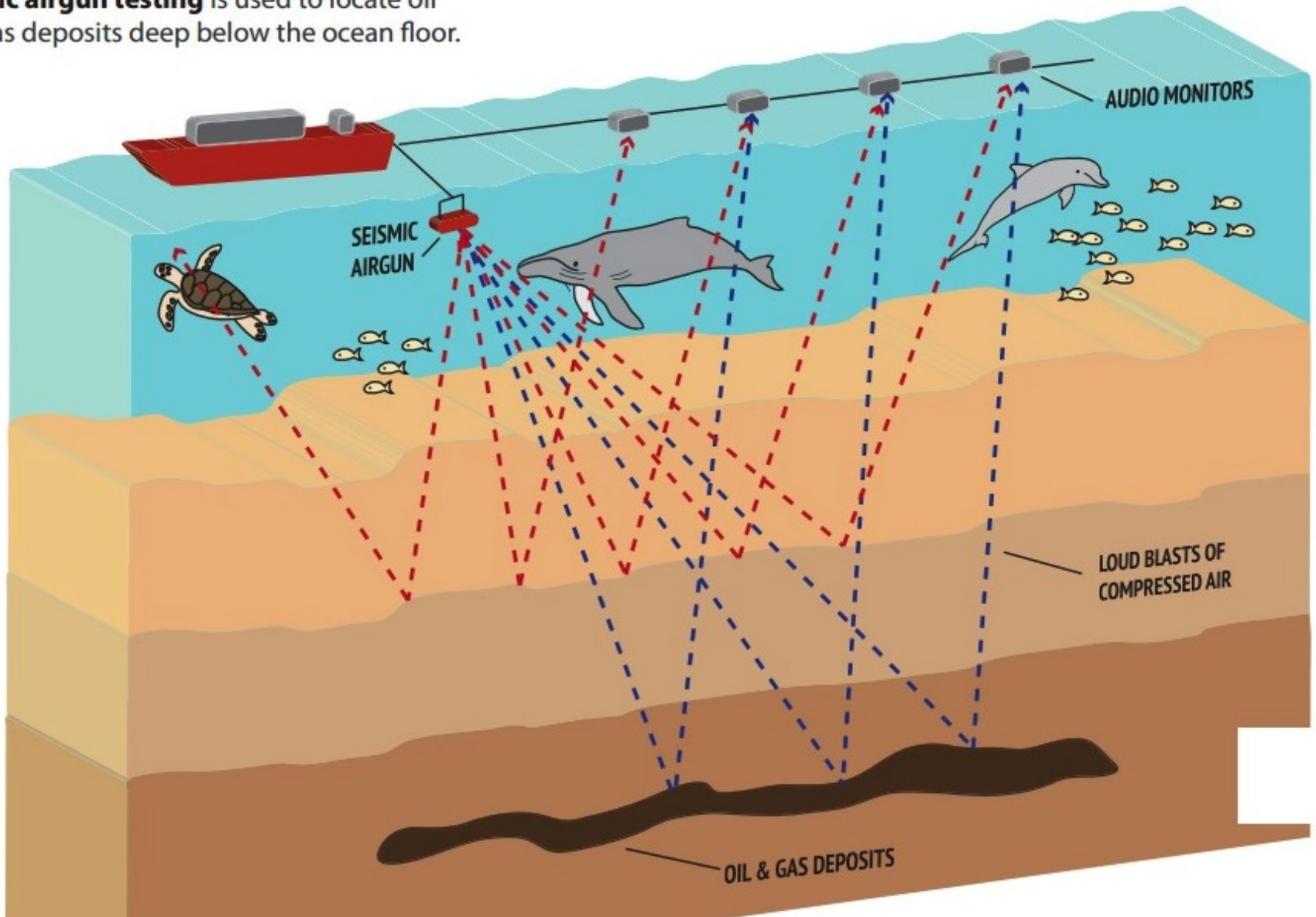


OIL – GAS - WATER - SOLIDS

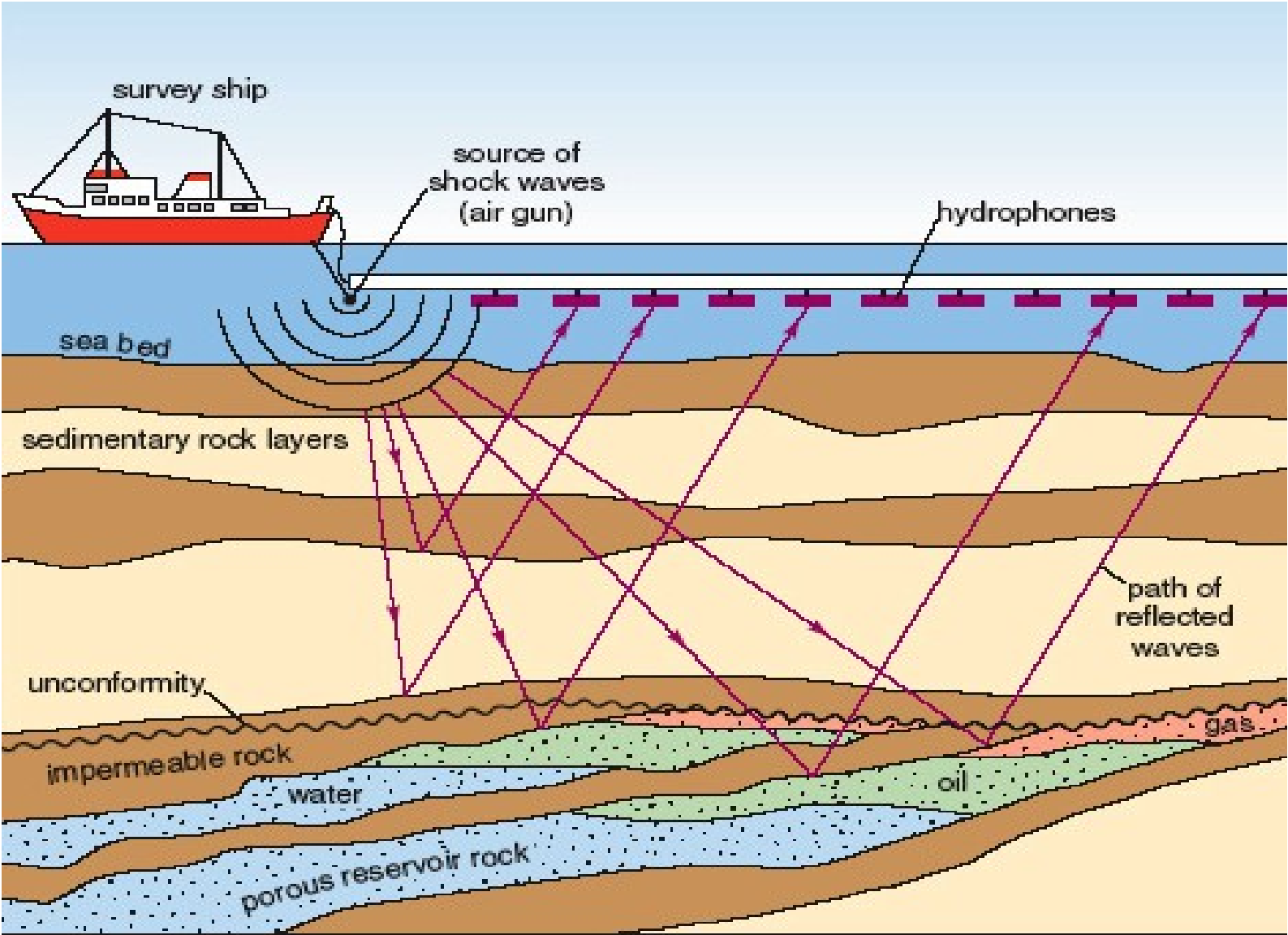
MANAGEMENT

Exploration: seismic research

Seismic airgun testing is used to locate oil and gas deposits deep below the ocean floor.

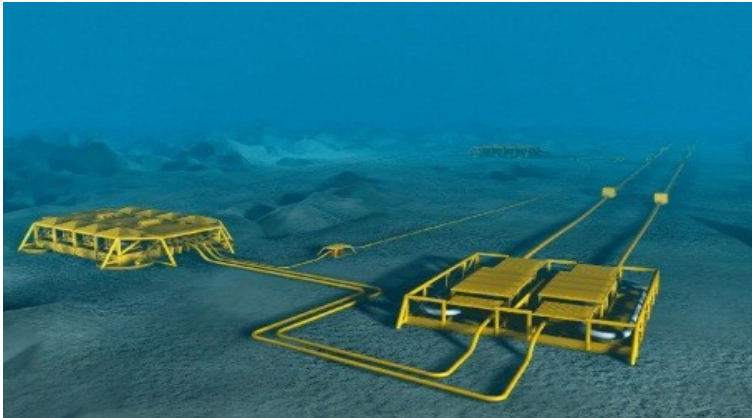


Seismic research



Exploration - Drilling - Production Norway

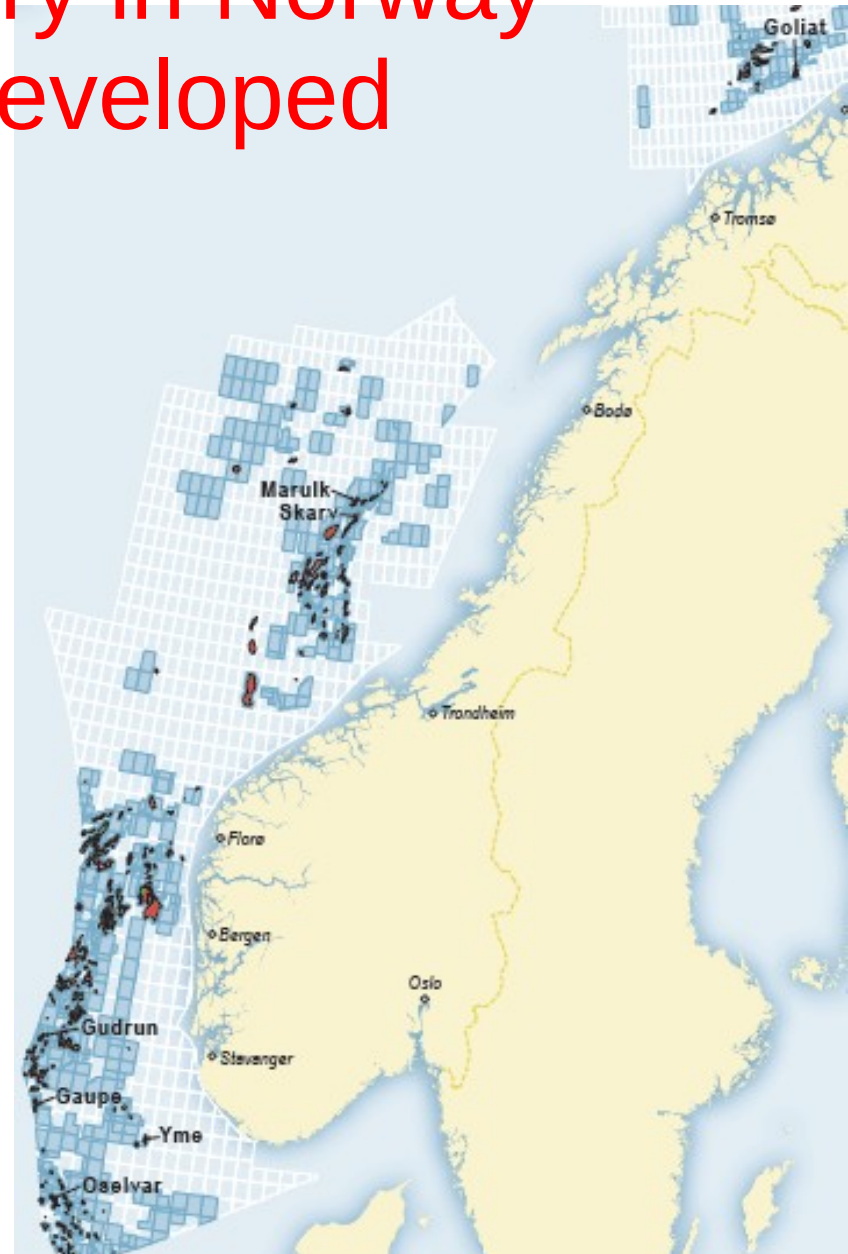
- 1.
- 2.
- 3.
- 4.
- 5.



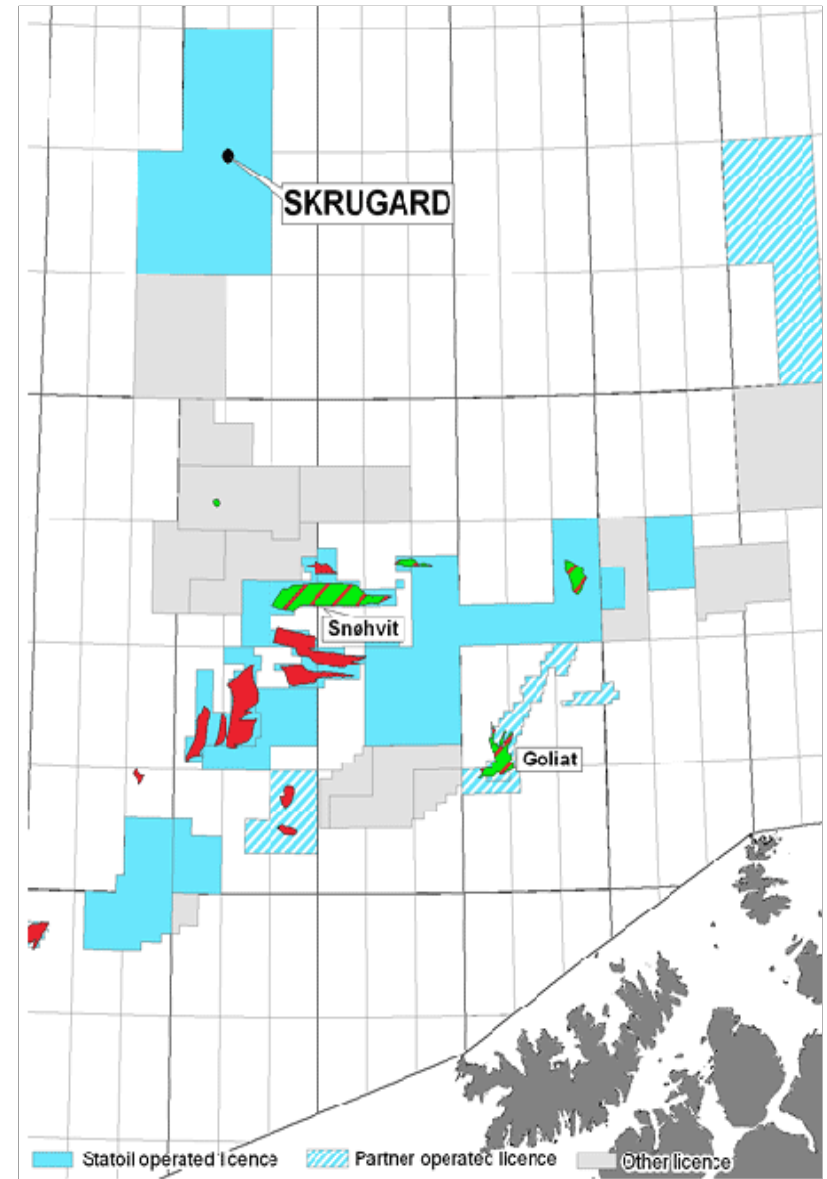
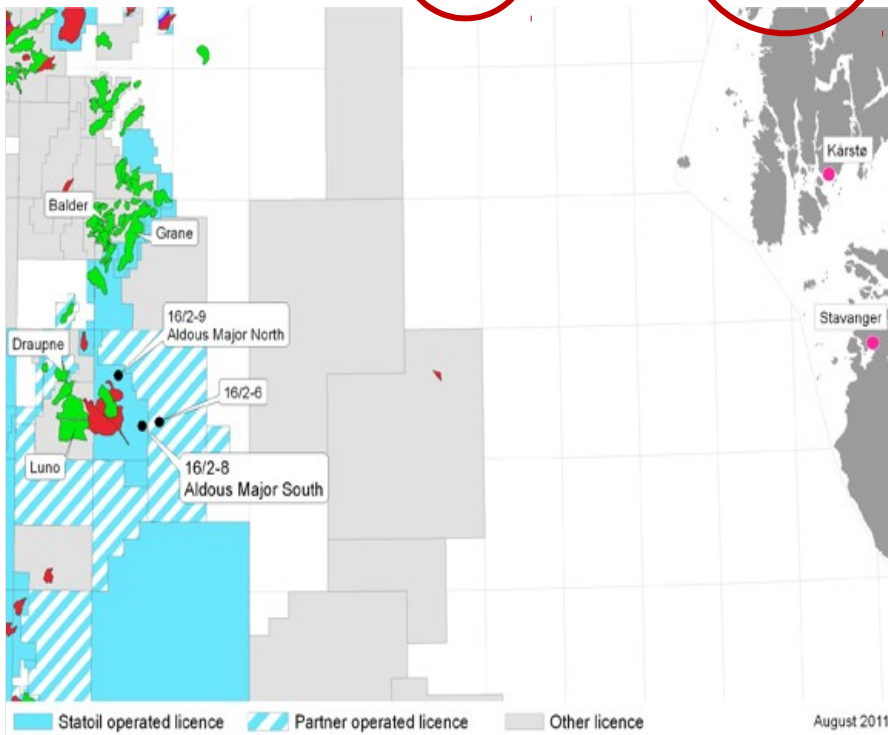
The drilling industry in Norway

Fields being developed

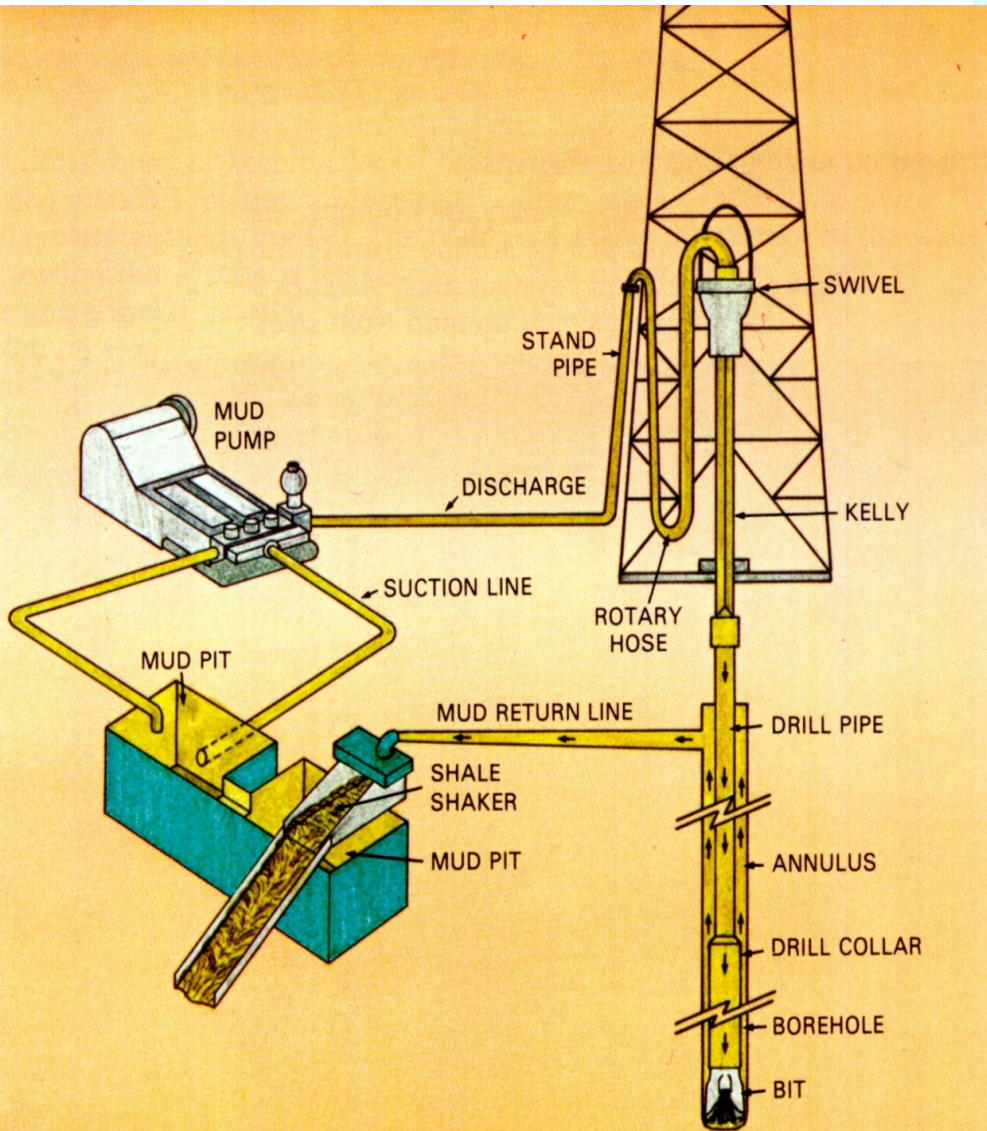
Name	Operator	Production start
Skarv	BP Norge	Q3 2011
Gaupe	BG Norge	Q4 2011
Oselvar	Dong	Q4 2011
Marulk	ENI Norge	Q2 2012
Vigdis North East	Statoil	Q4 2012
Goliat	ENI Norge	2013
Ekofisk South	ConocoPhillips	2013
Gudrun	Statoil	2014
Valemon	Statoil	2014



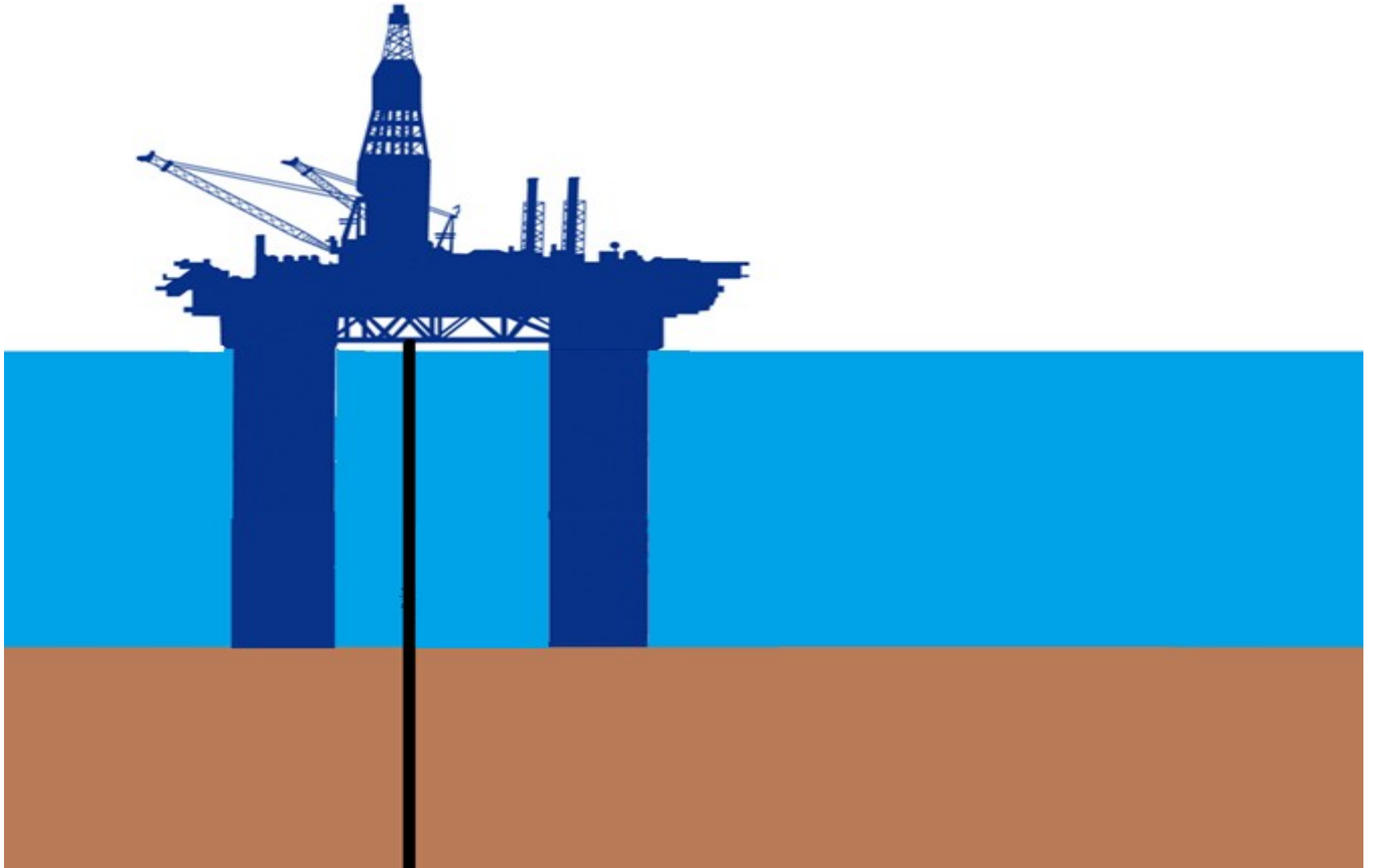
Largest discoveries in the World in 2011



Drilling \neq Production of oil and gas

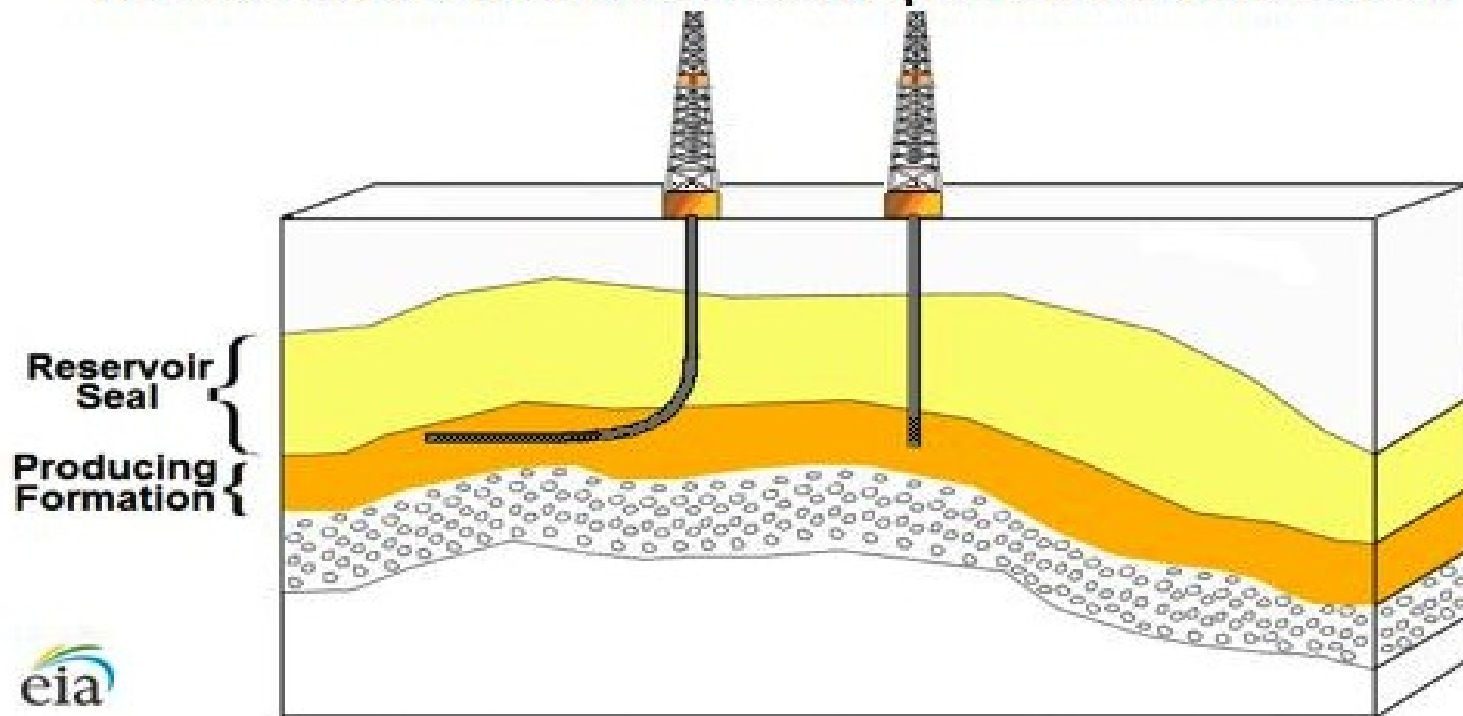


Schematics of Drilling Rig



Drilling operation: vertical and horizontal approaches

Greater length of Producing Formation Exposed to the Wellbore in a Horizontal Well as compared to the Vertical Well



Drilling compounds - what are they?

Oily water – Slop water (drilling slop)

+

Oily drill cuttings

Both are classified as Hazardous

+ non-oily drill cuttings

UiS

Drilling Slop

Slop is usually a mix of rain water and wash water with the remains of discarded drilling, completion and similar fluids

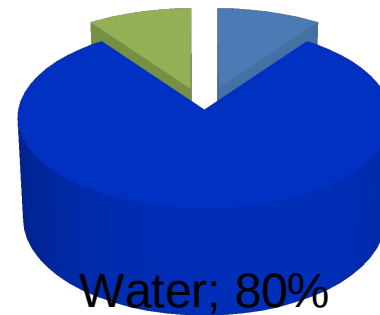
A typical rig produces 100 to 300 m³ every month

1000 m³ per month is not uncommon, depending on the operation



Solids; 10%

Oil; 10%



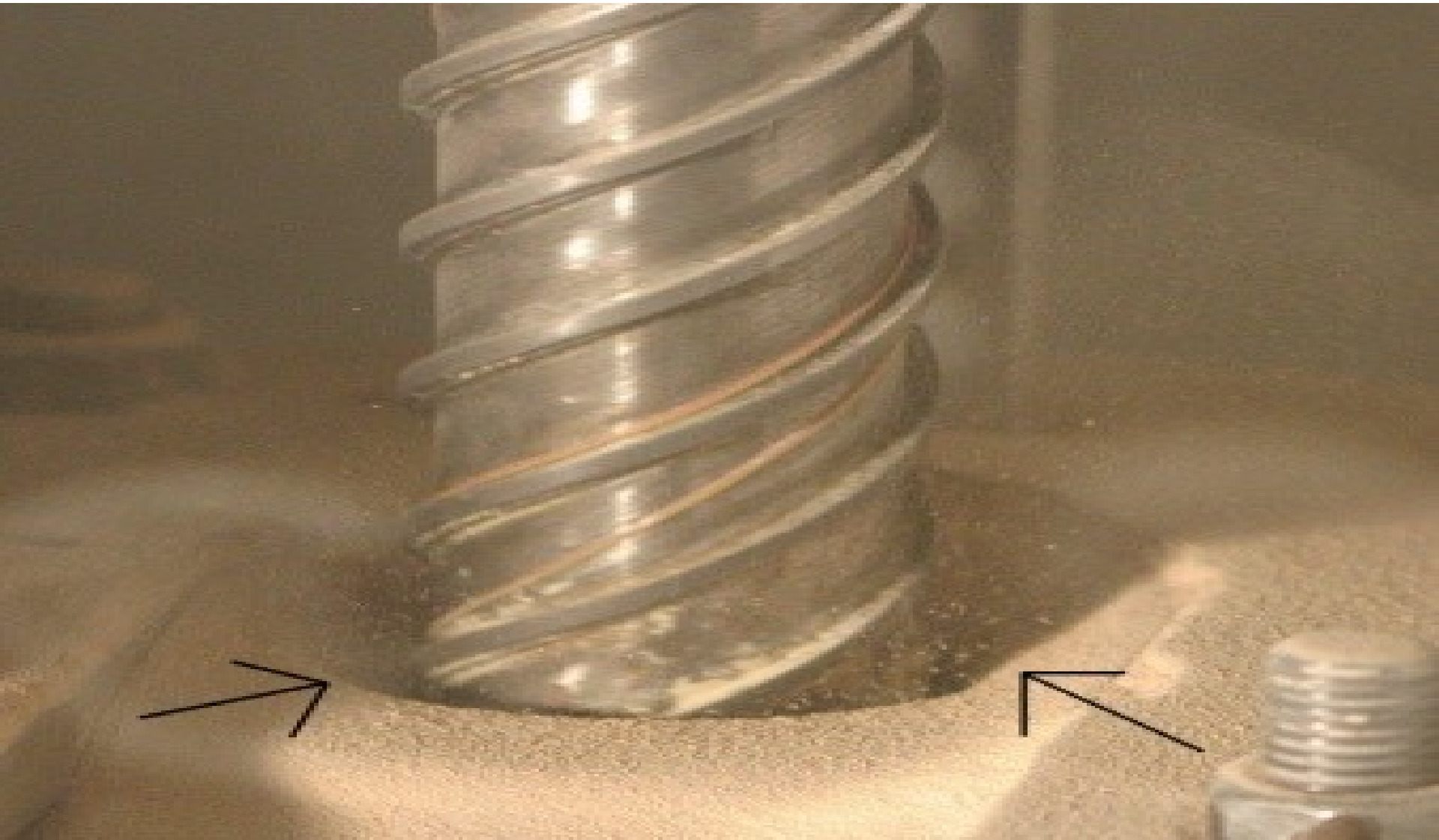
Water; 80%

Slop treatment challenges

- Product from drilling operations
- Large variation in quality and amounts
 - Collection system, drilling fluid, cleaning, ...



Cuttings removal from wells



Mud & Drilling



Separate cuttings from drilling mud



Muddy Drill Cuttings



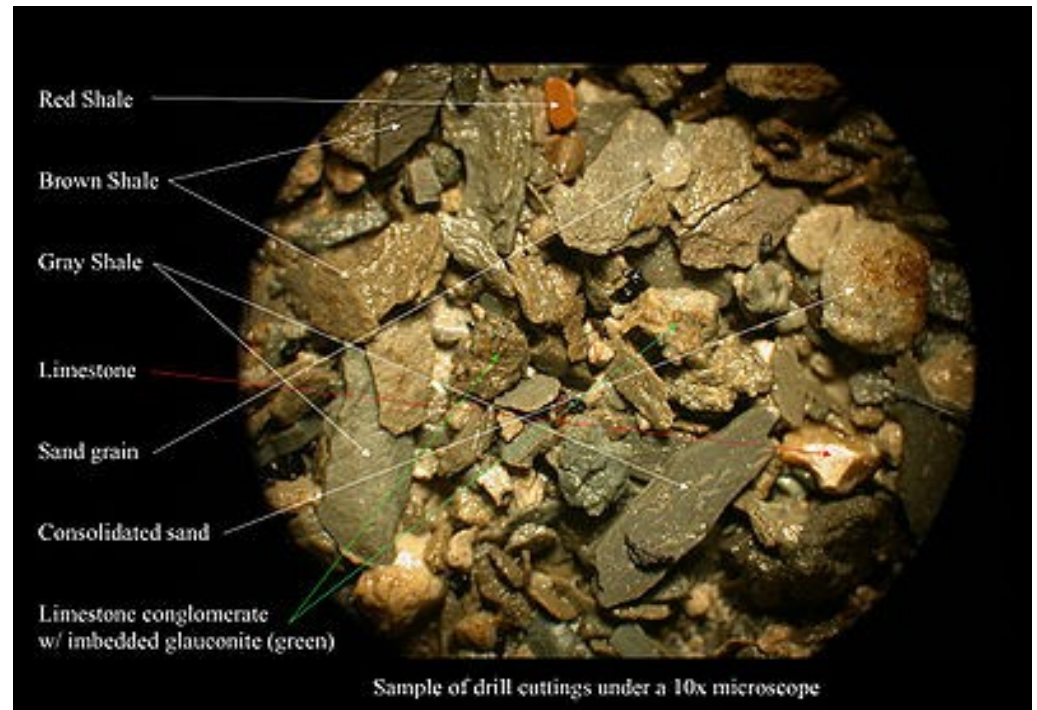
Drill Cuttings

- ✓ **Particles of crushed sedimentary rock produced during drilling operation**
- ✓ **Ground rock coated with a layer of drilling fluid**
- ✓ **A typical oil-based drilling fluid mix:**

70 % mineral solids

15 % water

15 % oil

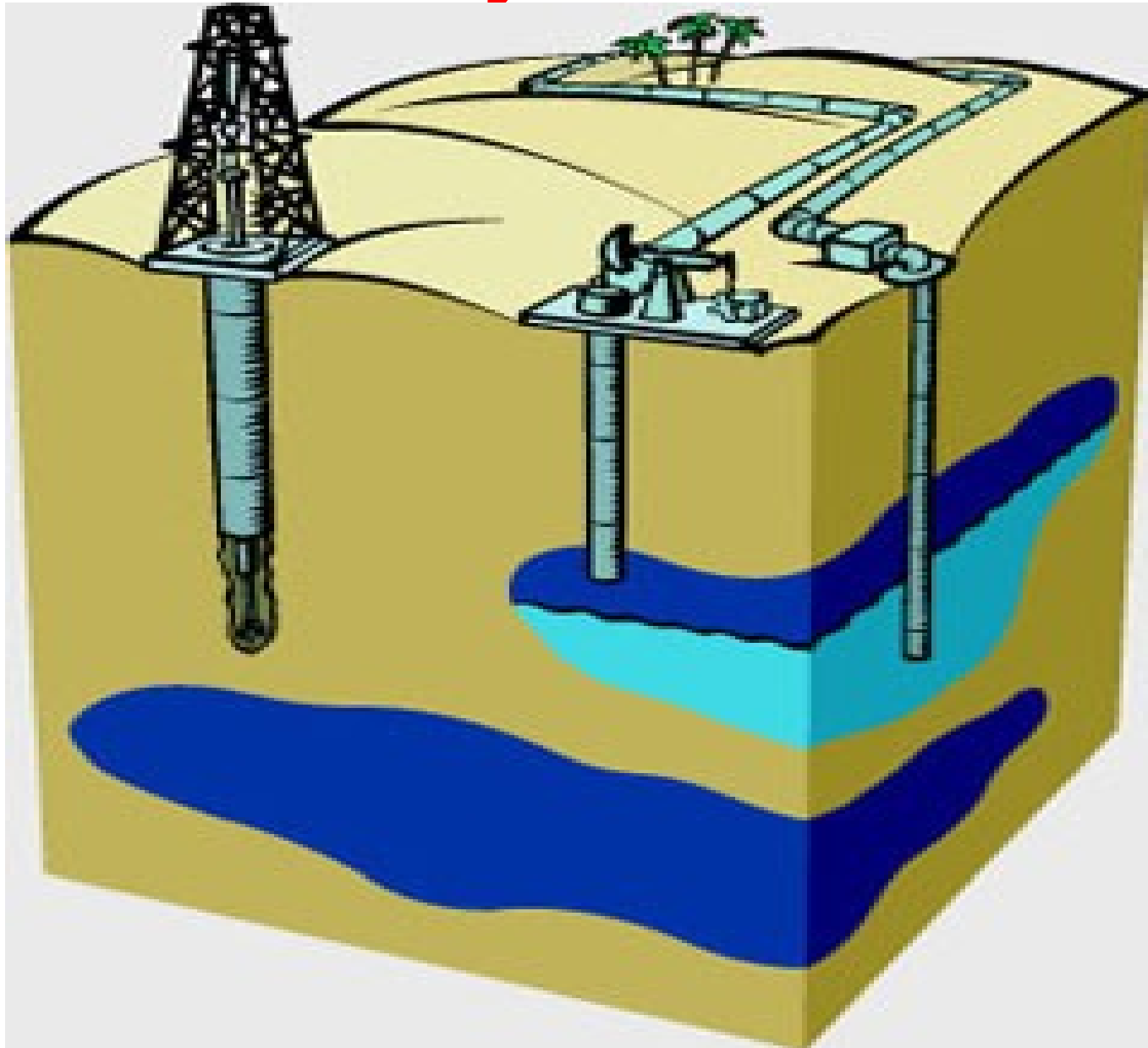


Sample of drill cuttings under a 10x microscope

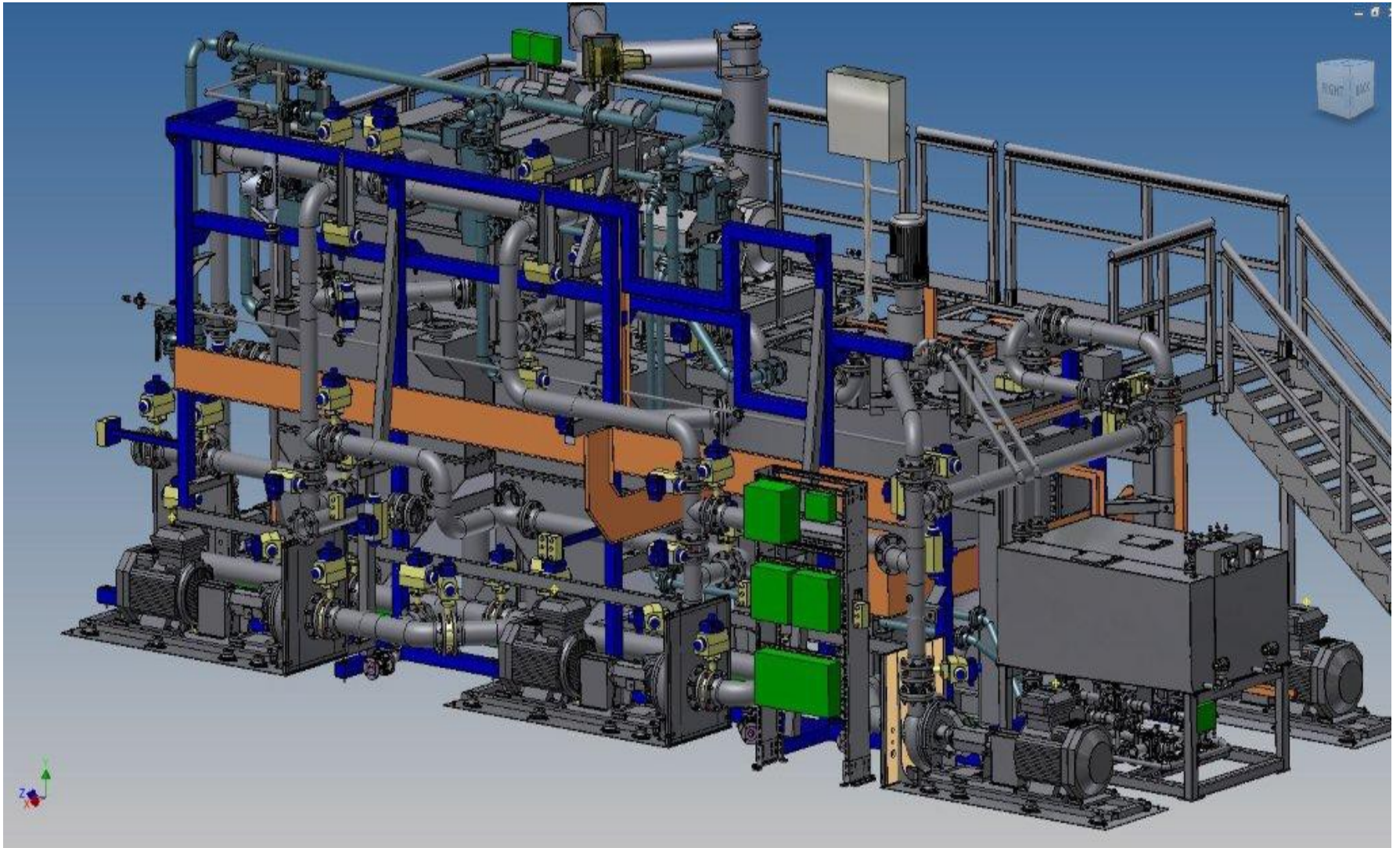
Drill Cutting & Solid Pulverizer



Re-injection

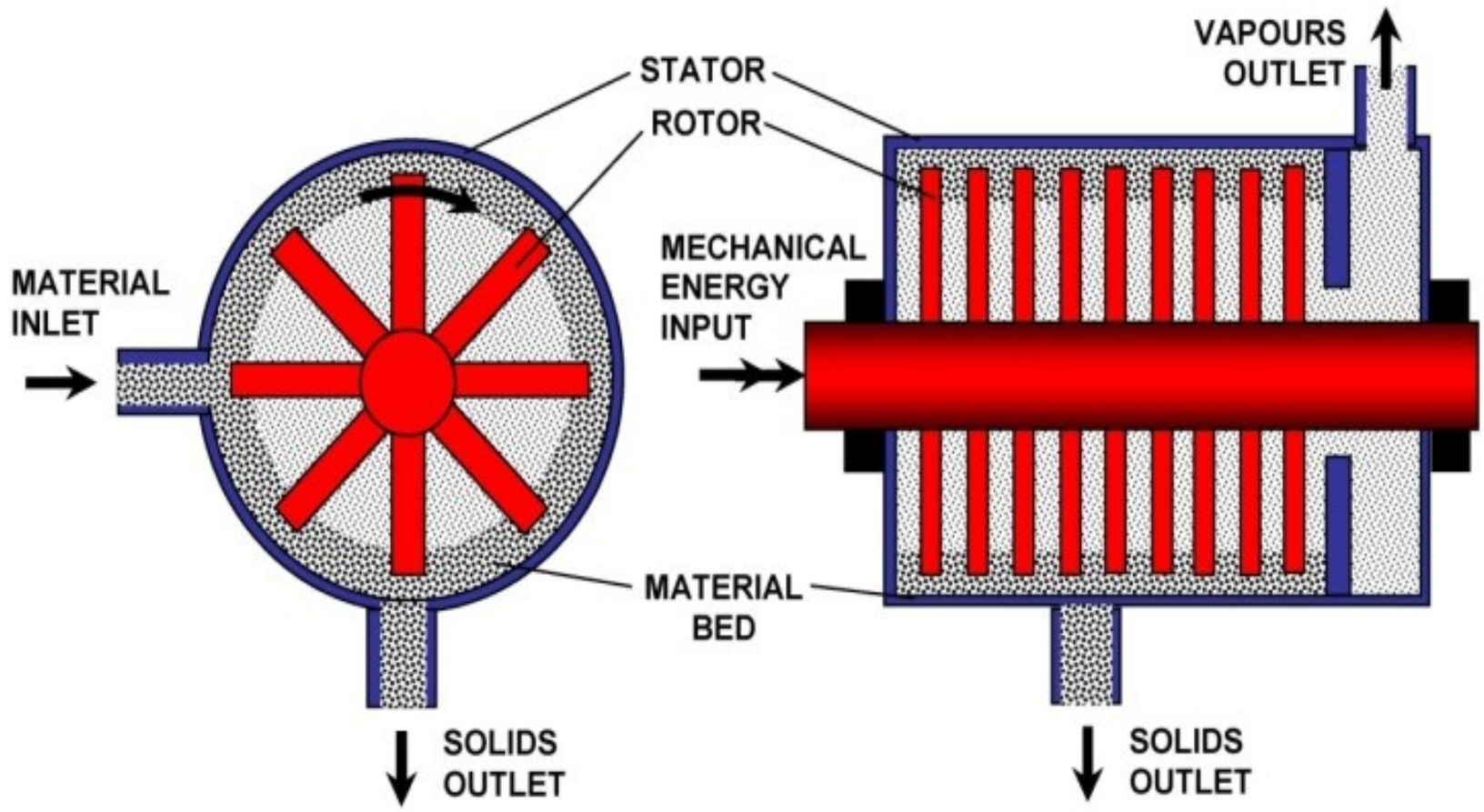


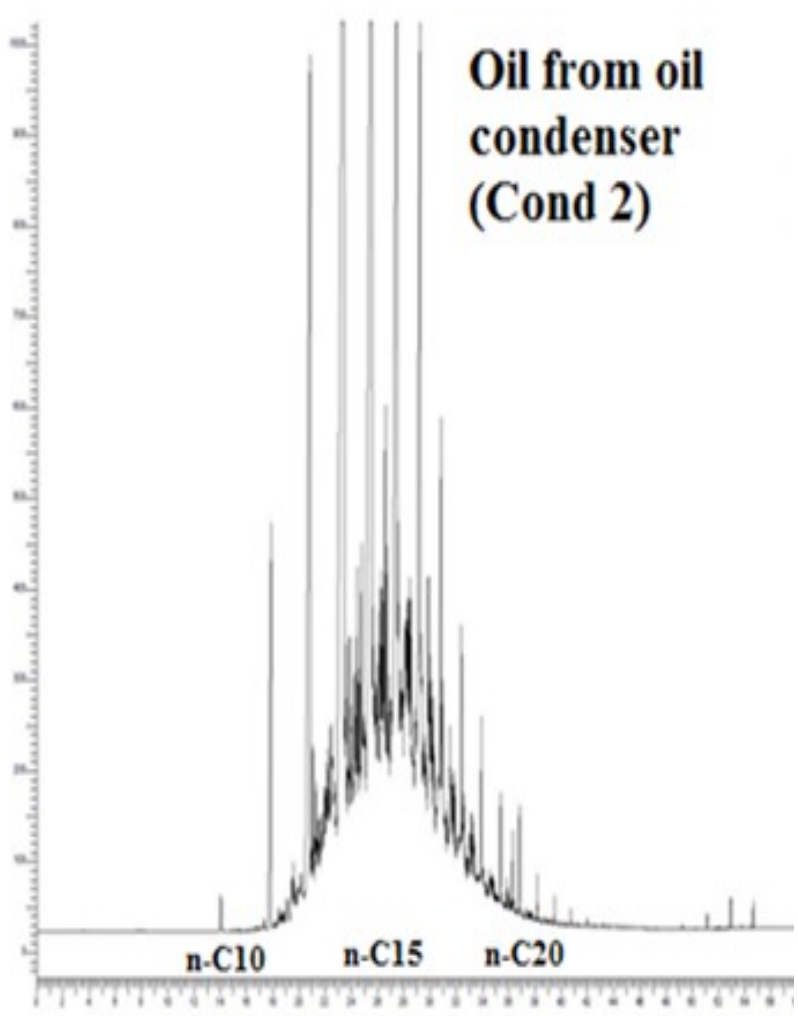
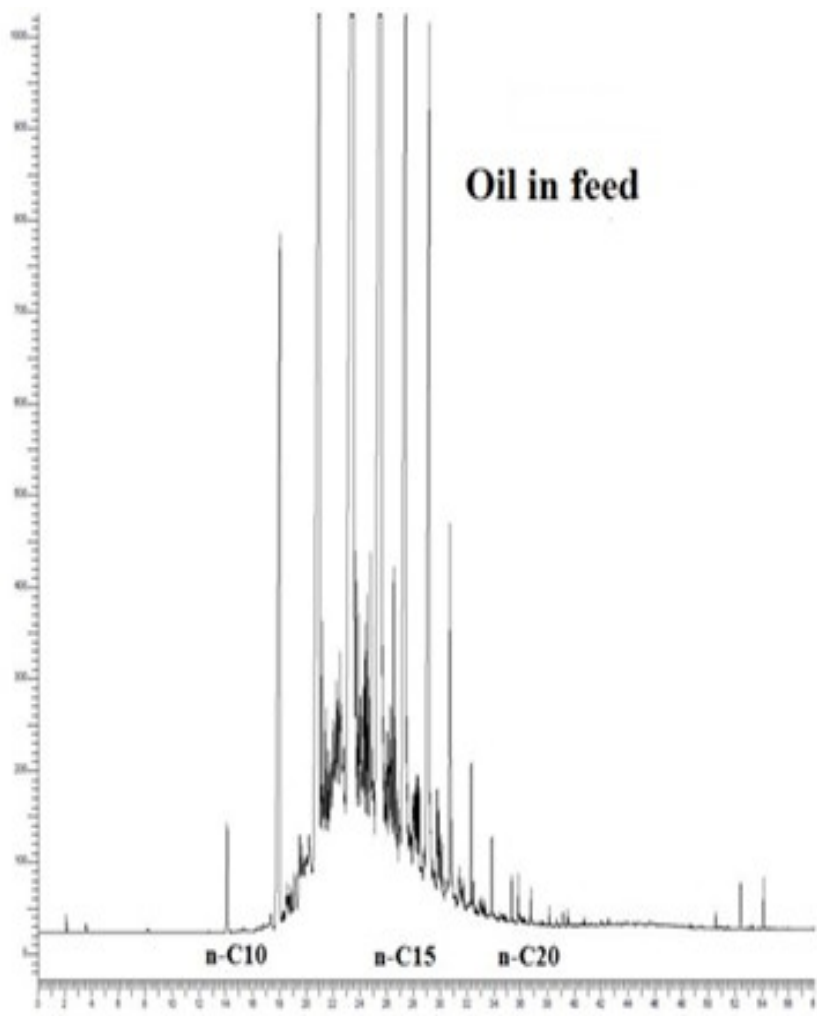
Oseberg B CRI – East side



Monitoring discharges of cuttings & mud







Summarize: Why drilling fluids?

Leif Erikson day rate 2014 = RP 4 600 000 000

NOK 2 800 000

Ariary 1 000 000 000



Why is still OBM used?

Deeper wells.

High inclination on the well increase the chance on fracturing the well.
Requires good well stability and efficiency

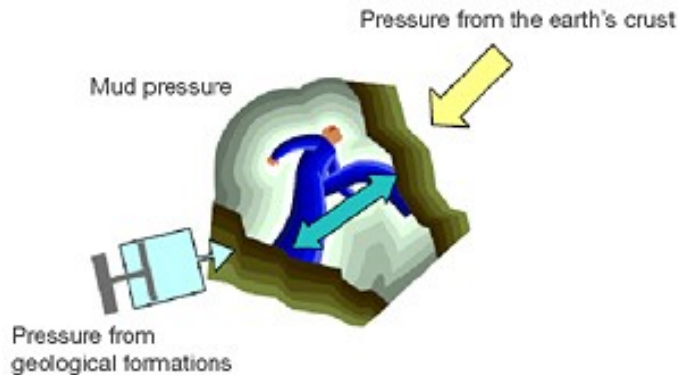
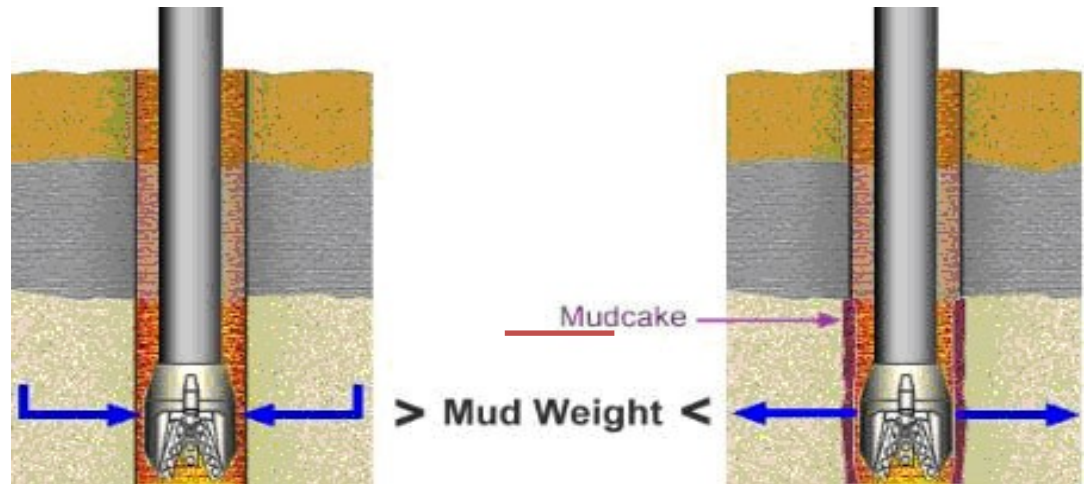
High recycle rate (70% , WBM 45%)

Personnel safety on Norwegian continental
Shelf is 1st priority

Drilling fluids are used when a hole is drilled

Why use drilling fluids?

-
-
-
-
-
-

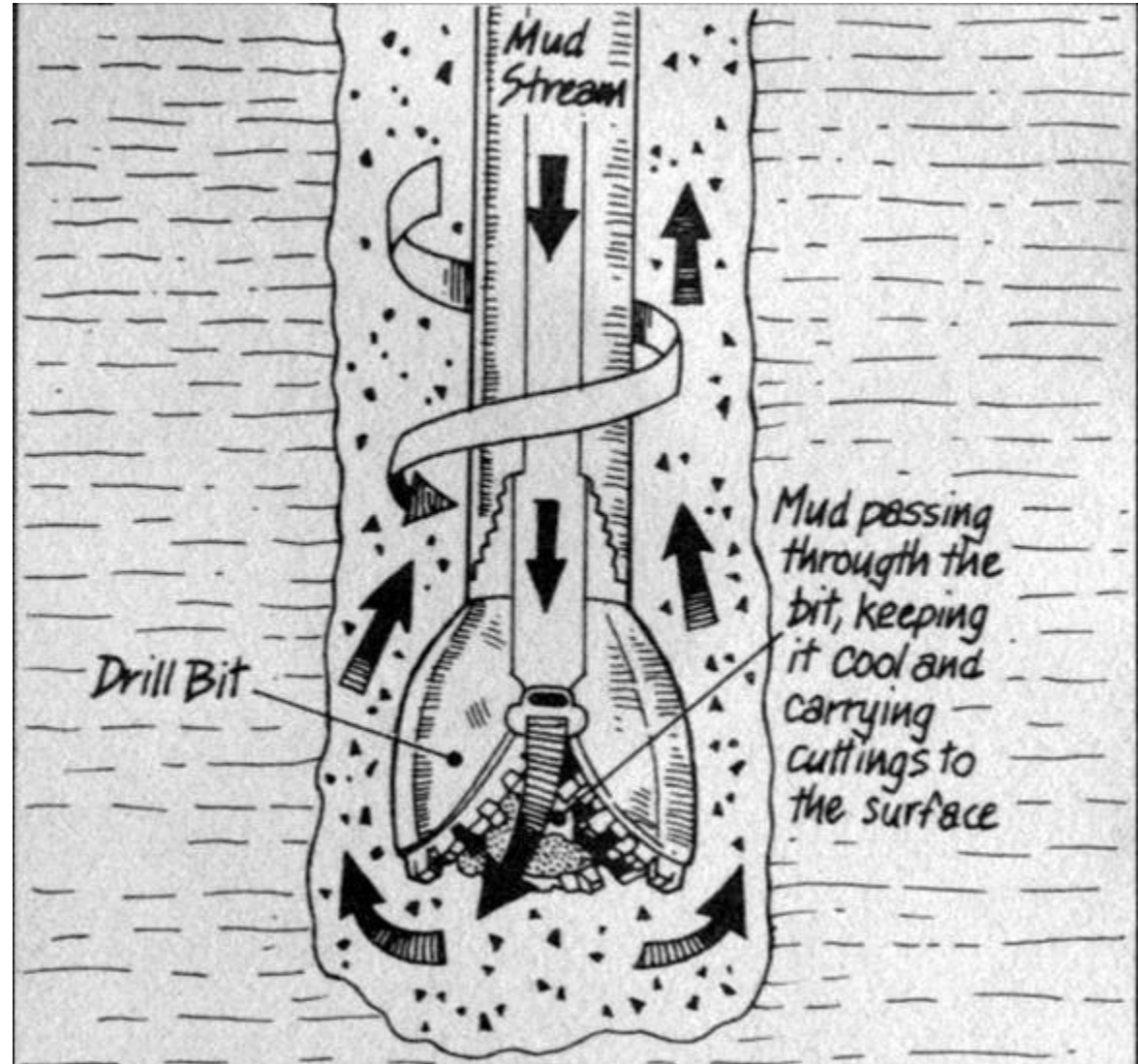


Why drilling fluids?

-
-
-

Remove cuttings
Cool

-
-

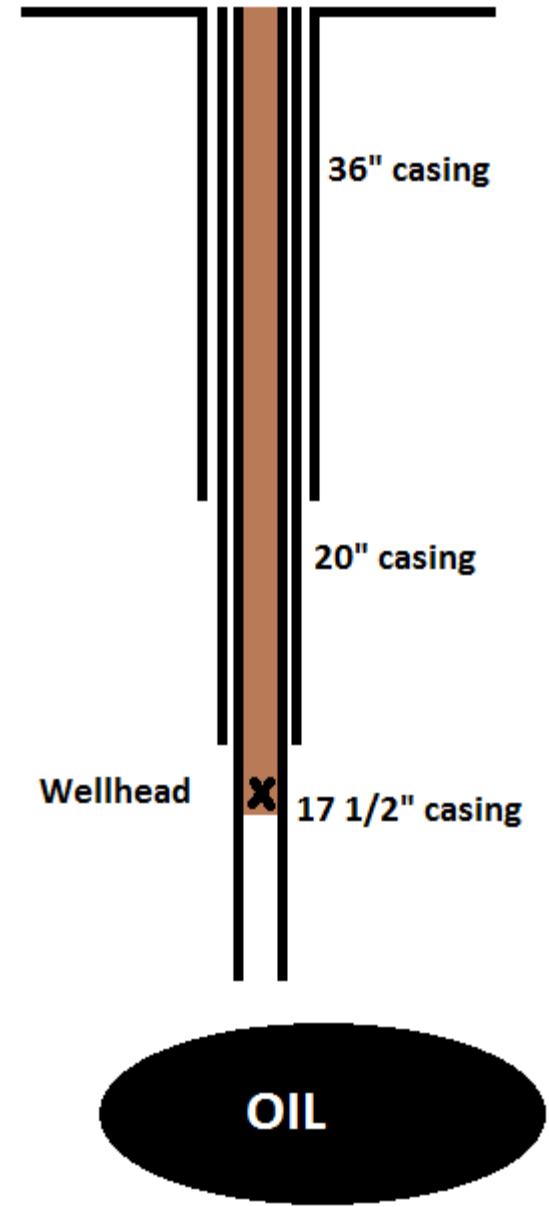


Why drilling fluids?

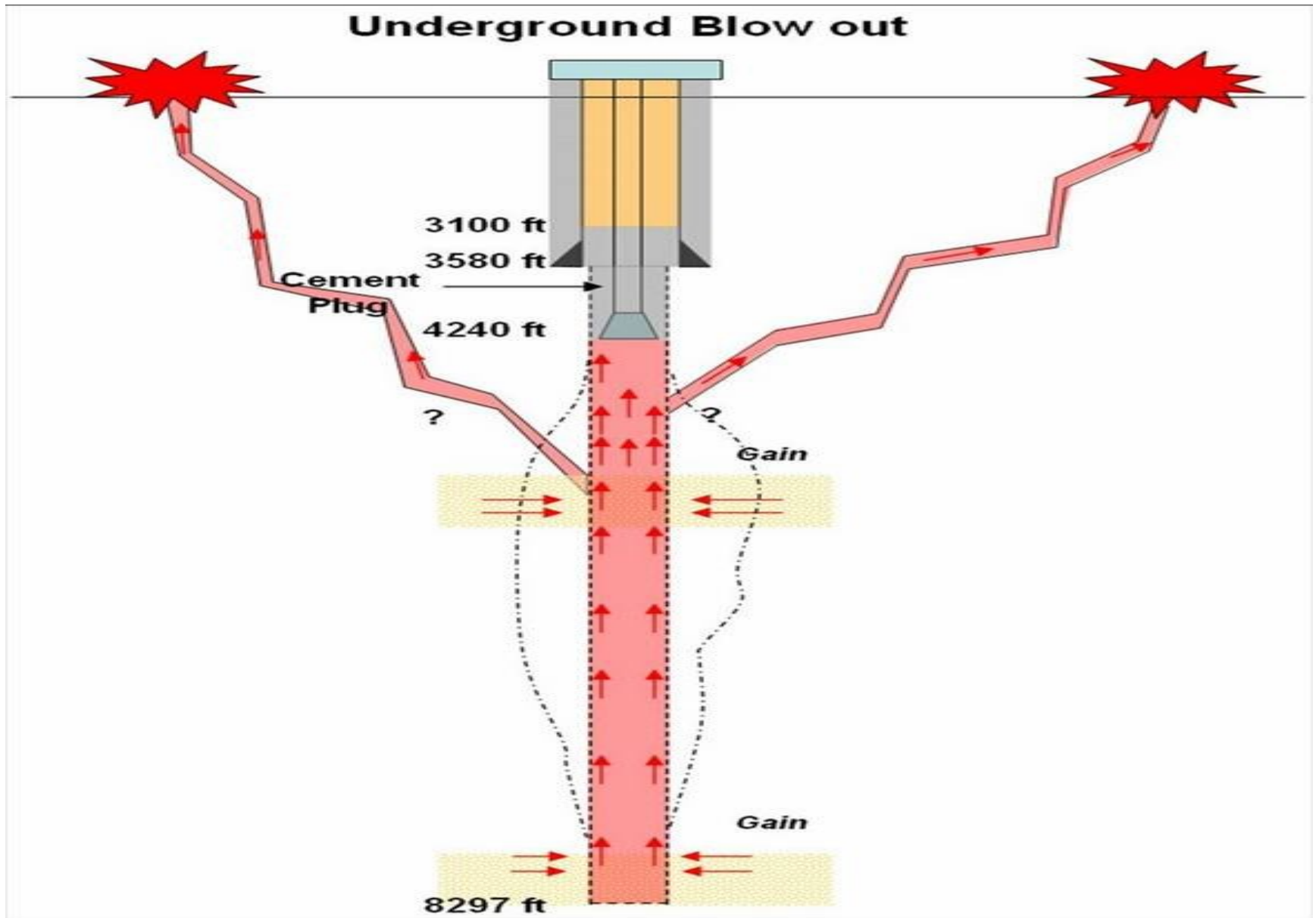
- -
- Stabilize for cementing**

MWD **LWD**

MWD = measurement while drilling
LWD = logging while drilling



Formation gas kick, no drill casing and “a wild well”



A continuous flow since 2006



100 000 people displaced



Indonesia

Lapindo Mud Volcano



Indonesians Anno 800 AC



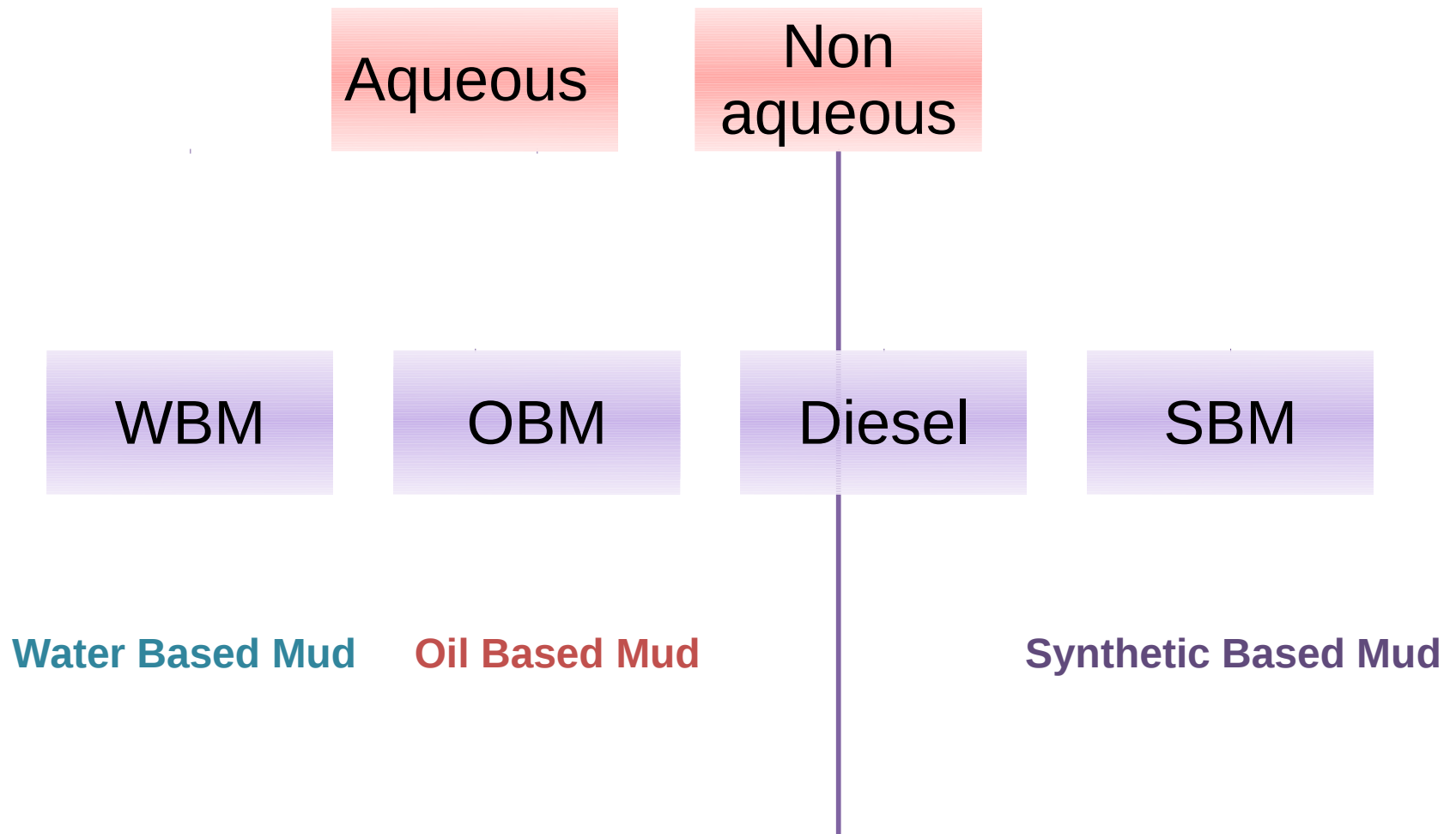


Sebaran Bahasa Austronesia

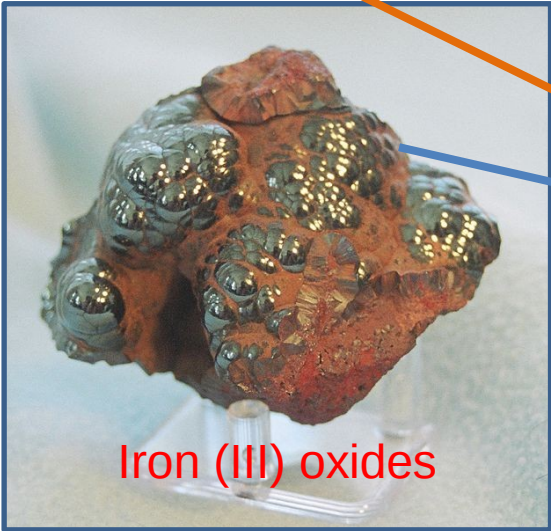
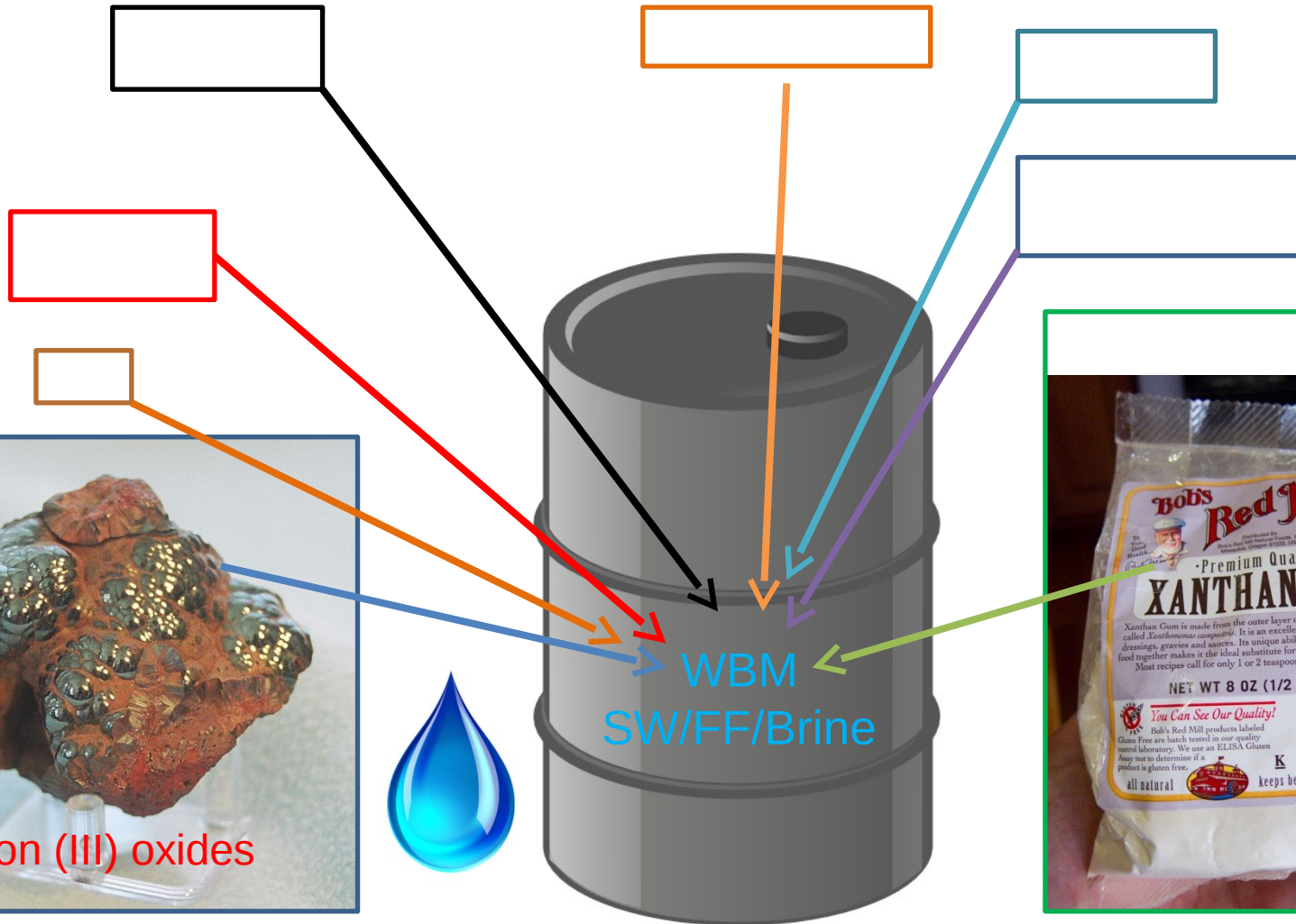
The Distribution Area of Austronesian Language Family

Did specify "why drilling fluids"

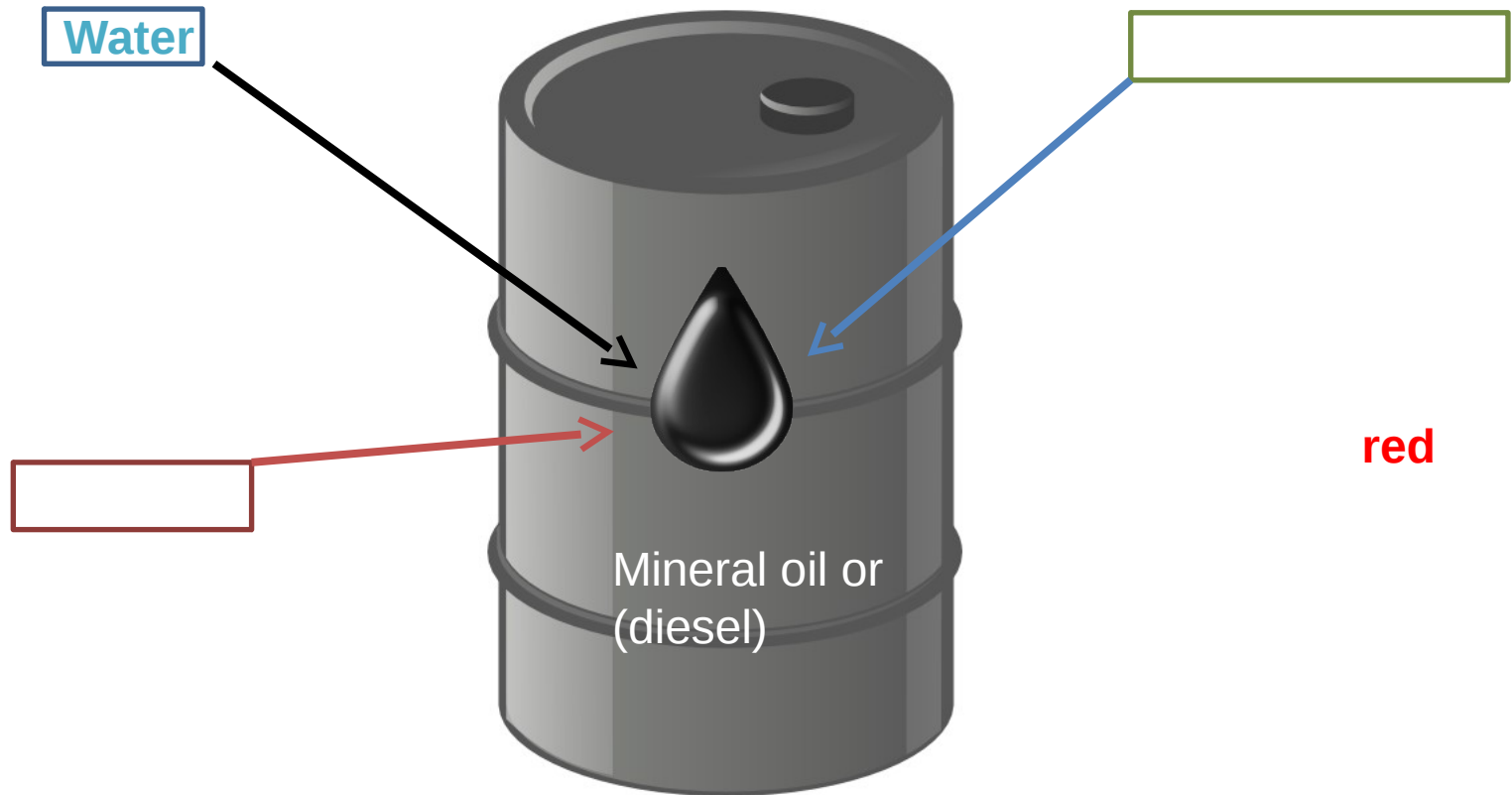
Now: **What are drilling fluids?**



Water Based Mud



Oil Based Mud



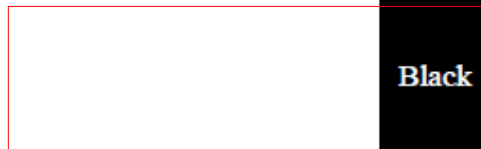
Modern WBM

Color Scheme Used by the Norwegian Pollution Control Authority to Classify Relative Hazard of Chemicals

SFT Color Category	Chemical Characteristics
Green	Chemical on the PLONOR list
Yellow	Unclassified chemicals, not considered hazardous
Red	<p>Chemicals recommended for substitution because:</p> <p>Two of three categories: biodegradability < 60%; $\log K_{ow} \geq 3$; Toxicity (ED_{50} or LC_{50}) ≤ 10 mg/L</p> <p>Chemicals on the OSPAR taint list</p> <p>Inorganic chemical toxicity (EC_{50} or LC_{50}) ≤ 1 mg/L</p> <p>Biodegradability < 20%</p>
Black	<p>Chemicals prioritized for substitution (White Paper No. 25, 2002-2003, Table 8.1), including:</p> <p>Hormone disrupting chemicals</p> <p>Biodegradation < 20%, $\log K_{ow} > 5$</p> <p>Biodegradation < 20%, toxicity (EC_{50} or LC_{50}) < 10 mg/L</p>

Pose little or no risk to the environment

Bioaccumulation

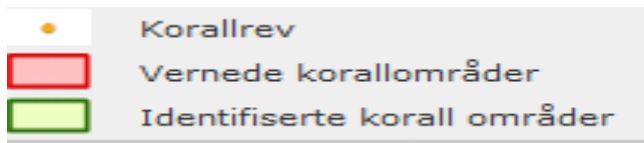


Black

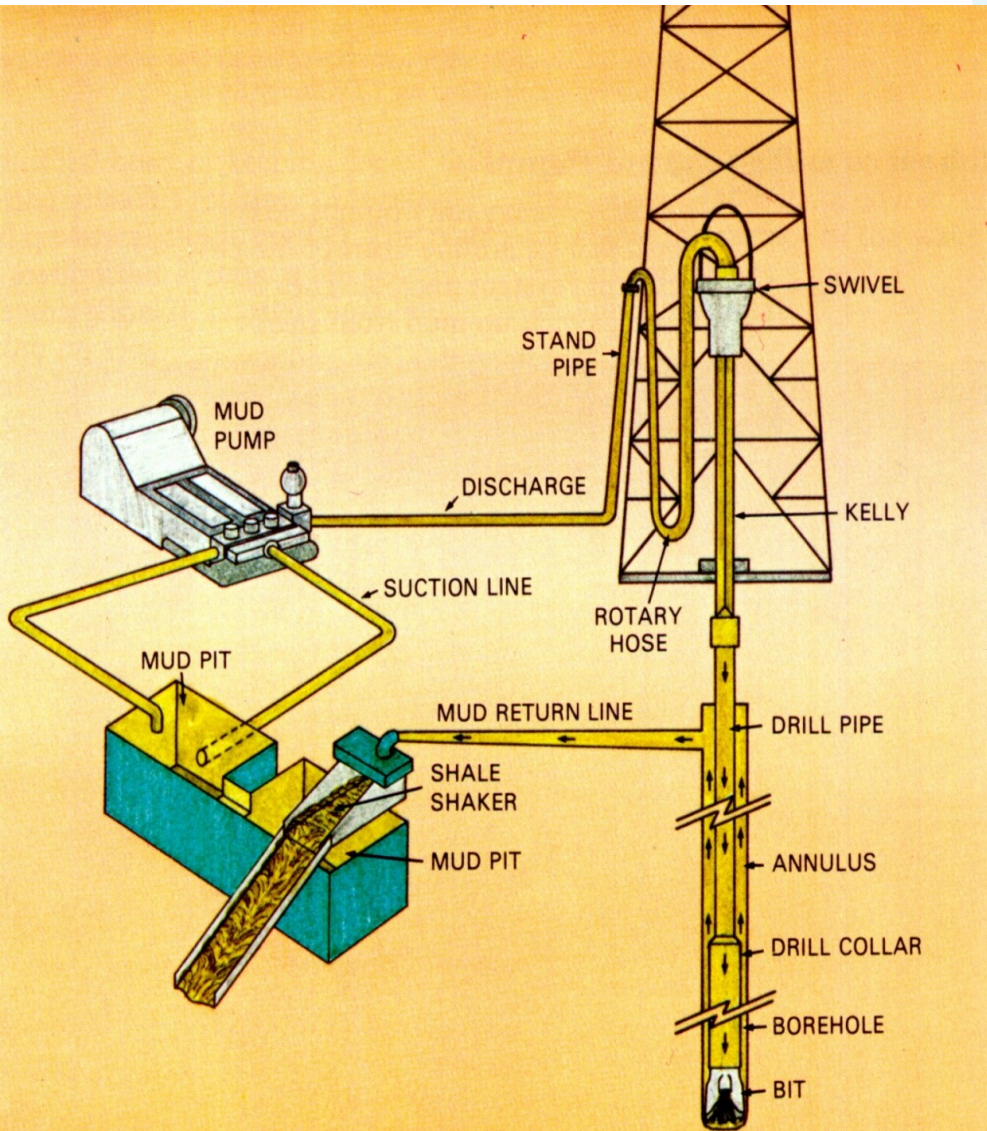
Is Oil Based Mud really that bad?

Spawning grounds for fish are damaged by drilling discharge

Norway has big coral reefs (*Lophelia pertusa*)



Drilling \neq Production of oil and gas



Crude oil flow

Earthen storage pits

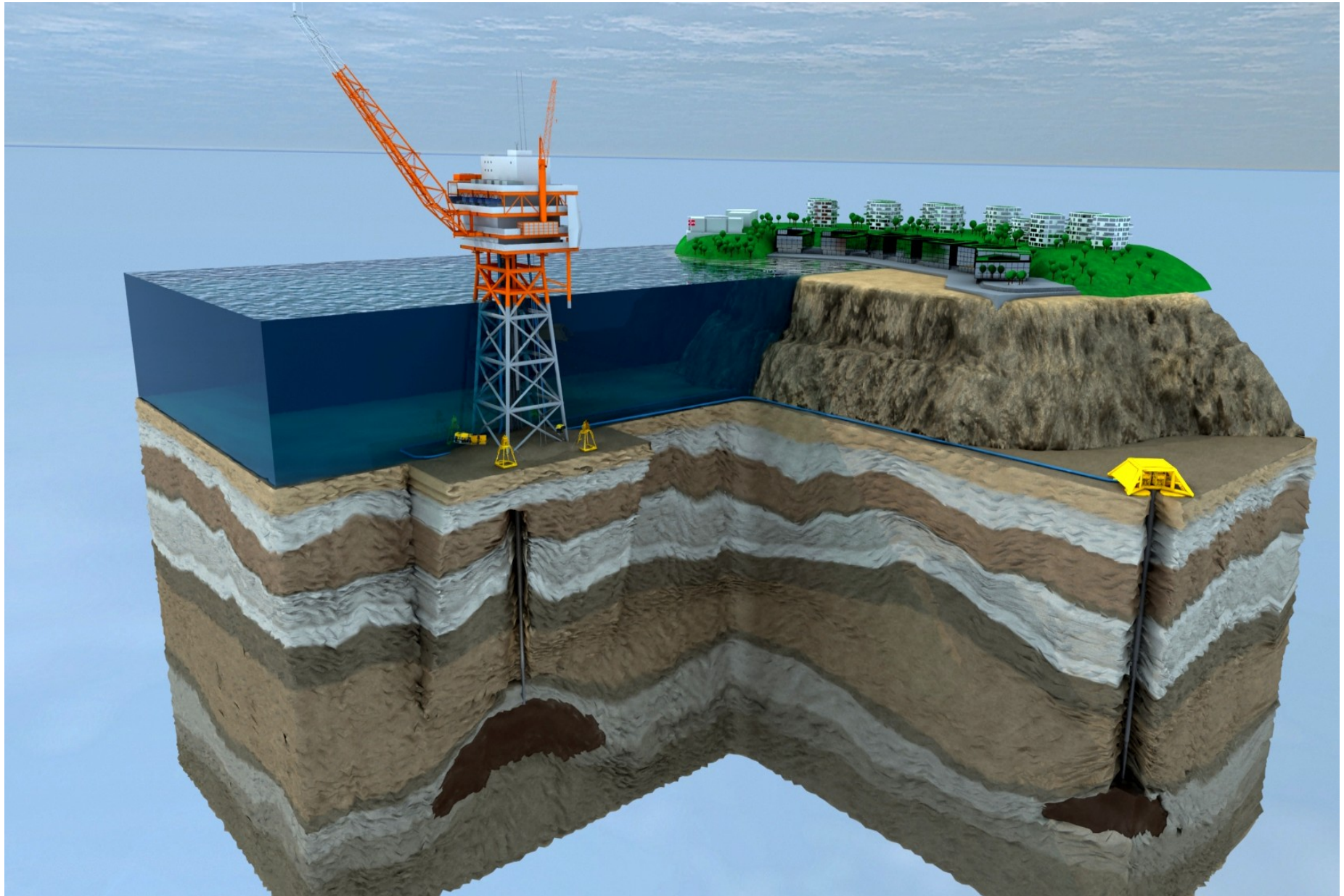




Flow of crude oil from well



Platform production and subsurface operation



Ospar: 720 installations



Decommissioning/reuse

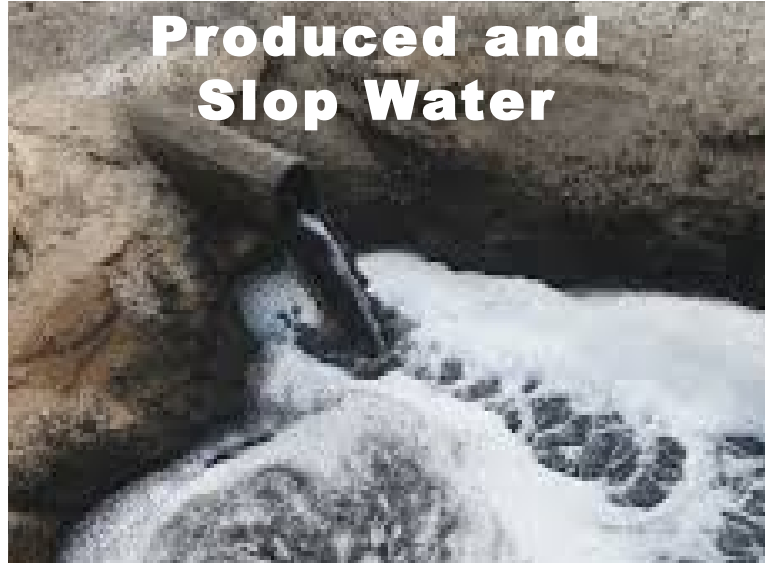


Separation Technology Produced Water Treatment



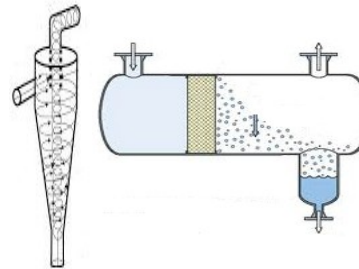
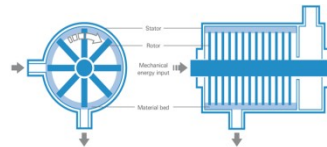
INPUT

Produced and Slop Water



TREATMENT

- Hydrocyclone
- Coalescer
- TCC



OUTPUT

Solids re-use:

- Construction works
- Road buildings
- Landscape design



Water re-use:

- Release into sea
- Re-injection to maintain pressure
- Design of «smart water» to increase oil recovery



Oil re-use:
depends on
quality



Produced water treatment



Klikk for å redigere tekststiler i malen

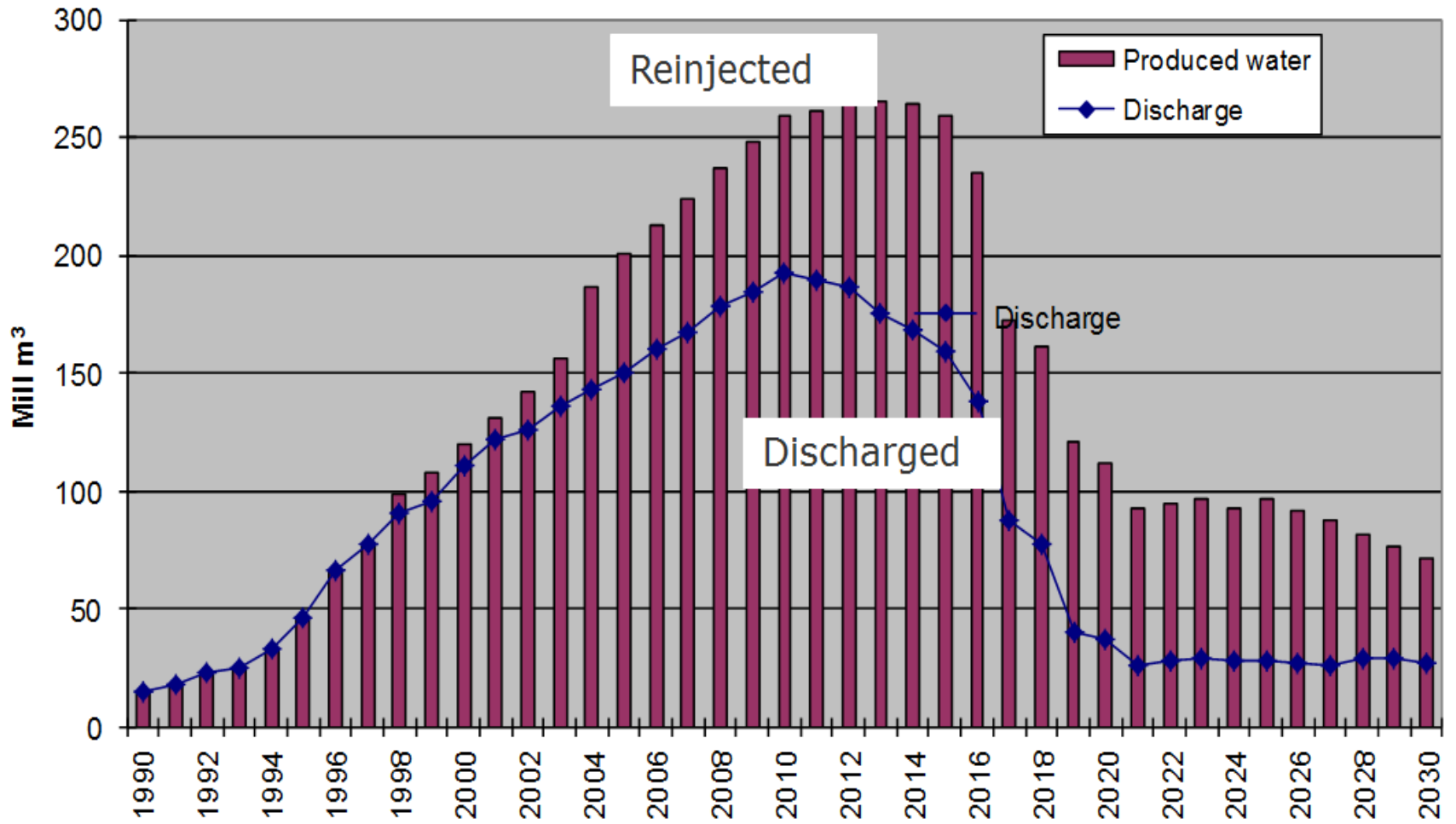
Andre nivå

● Tredje nivå

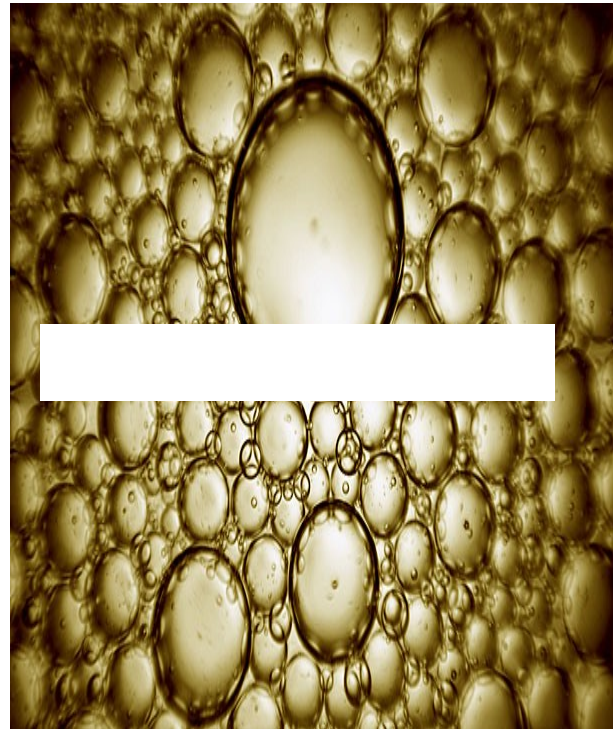
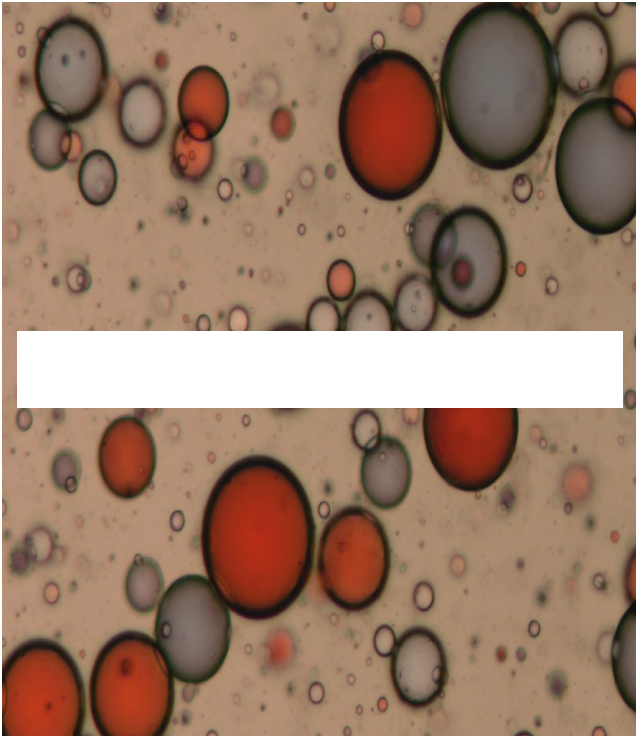
● Fjerde nivå

● Femte nivå

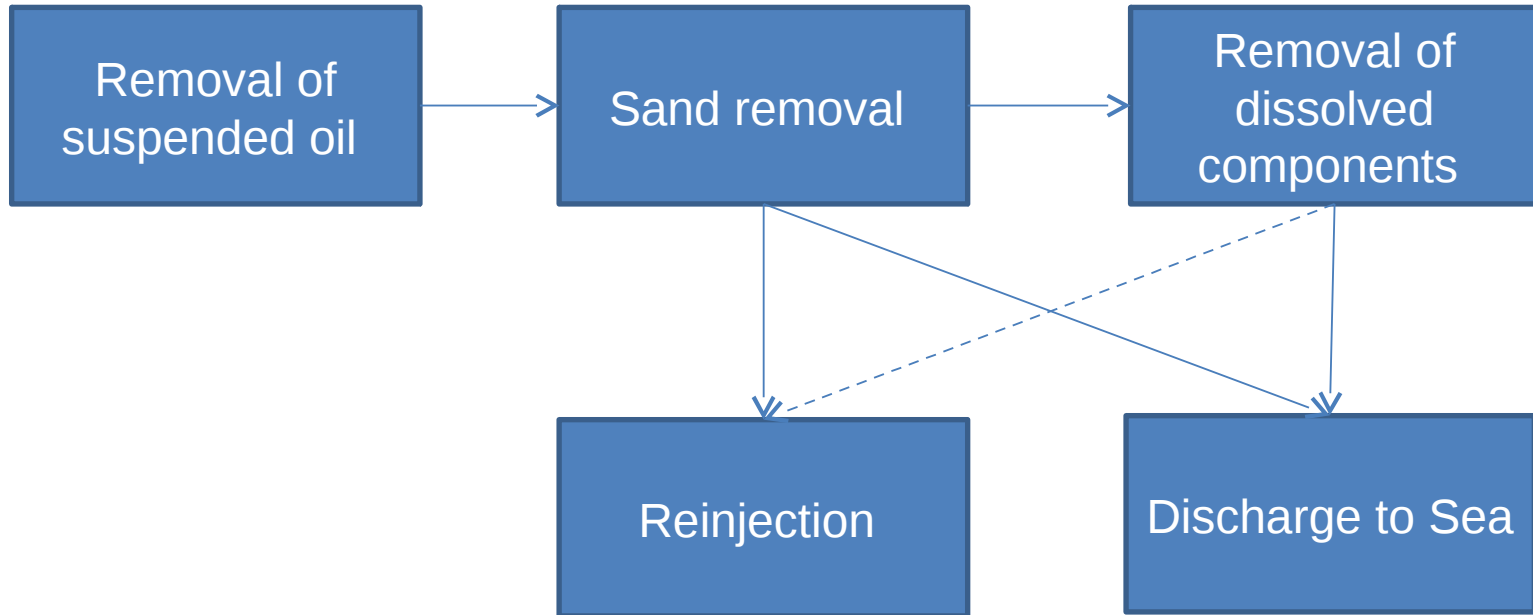




Challenges: Droplet size and Emulsions



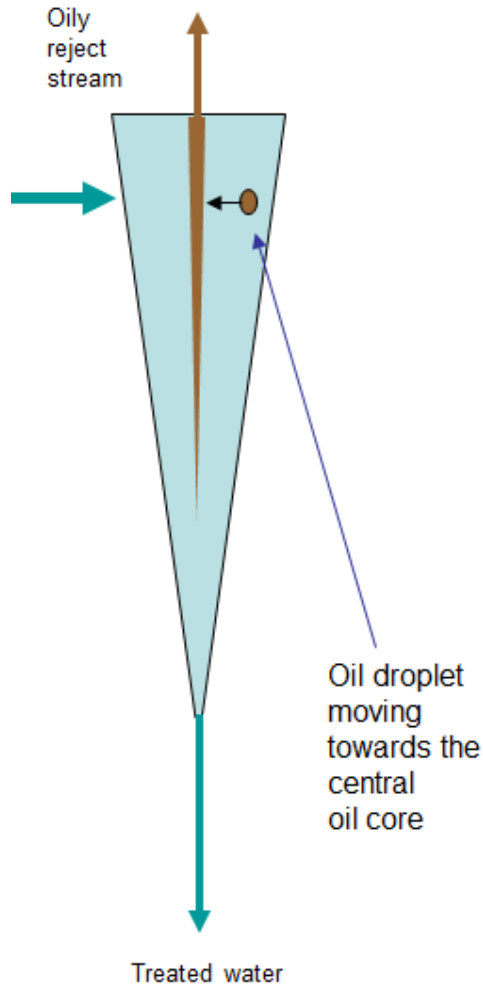
Produced water treatment



International Environmental Discharge Limits of Oil in Water

Location	Maximum Oil Concentration (mg/L)
North Sea	30
USA Offshore Effluent Guidelines (EPA)	29 average (42 maximum)
NE Atlantic & Arctic Oceans	40
Mediterranean Sea	10 - 15
Caspian Sea	20 (under review)
Red Sea	15
Nigeria	15 onshore; 30 offshore
Indian Ocean (BH)	48
Western Australia	30 (50 maximum)

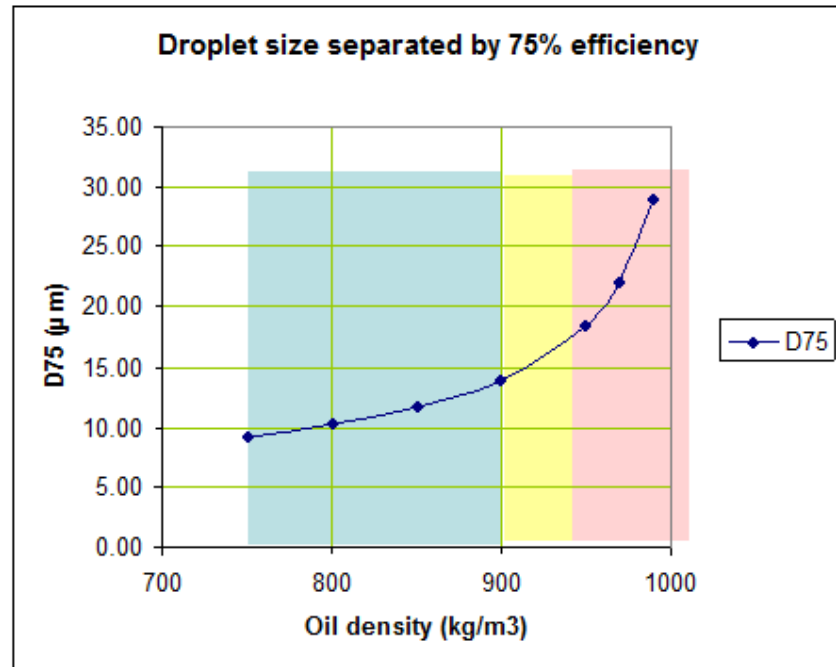
Separation of oil droplets - Stoke's law



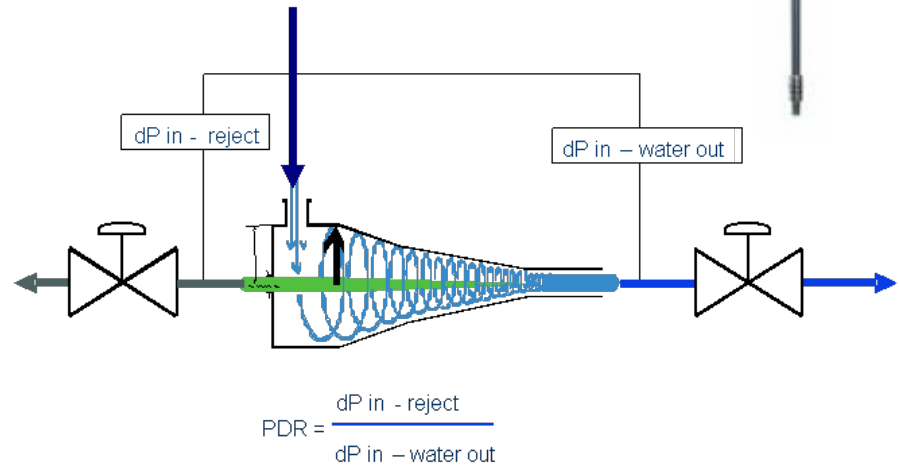
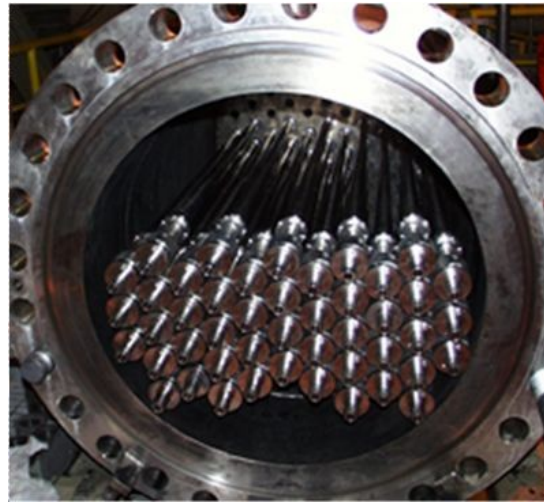
Deoiling hydrocyclones

$$v_s = \frac{g (\rho_p - \rho) D_p^2}{18 \mu}$$

ρ_p : particle density
 ρ : fluid density
 D_p : particle diameter
 μ : fluid viscosity

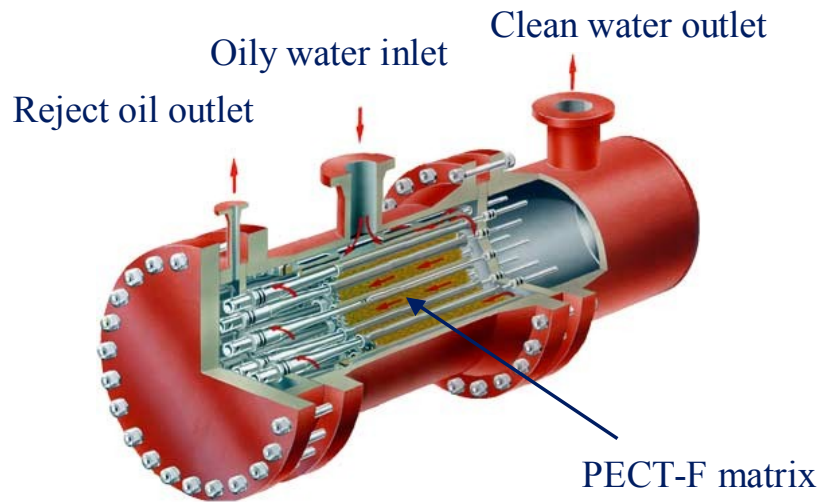


Hydrocyclones



Droplet Coalescences Technologies

Pect-F

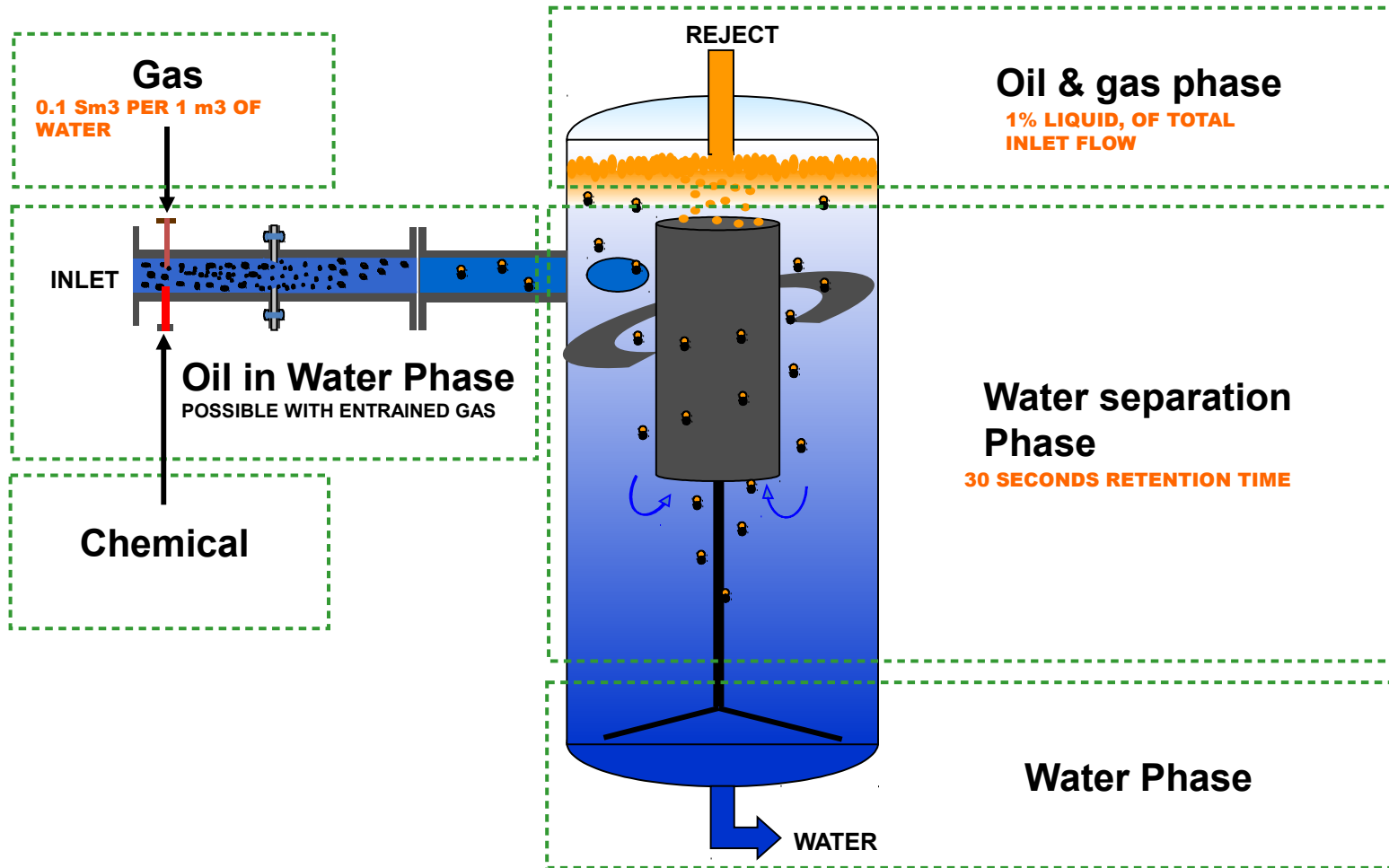


Mares Tail



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-
-

Compact Floatation Unit (CFU)

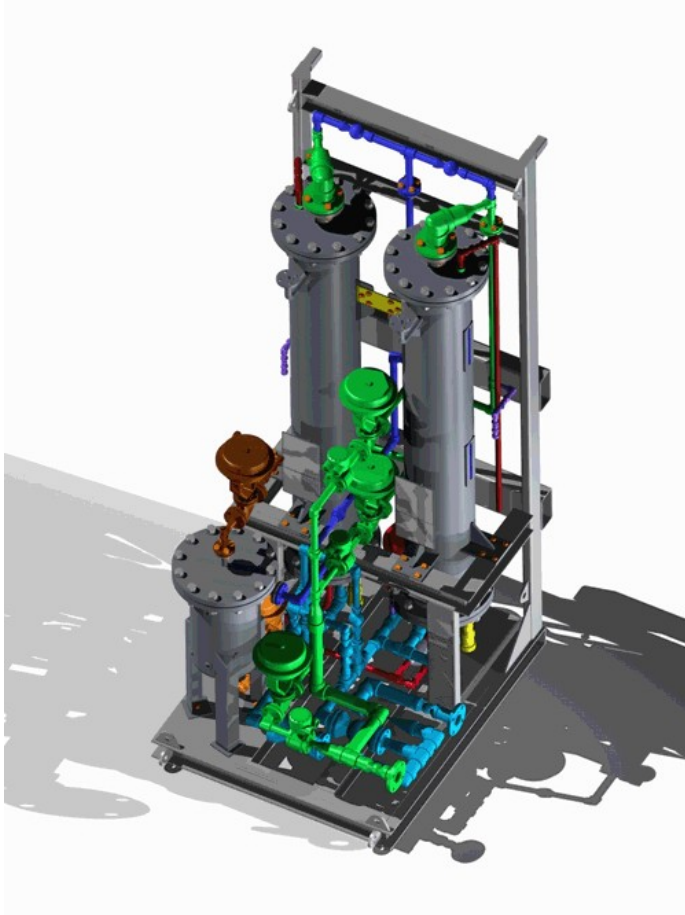


Epcon CFU Plant



Walnut Shell Filter

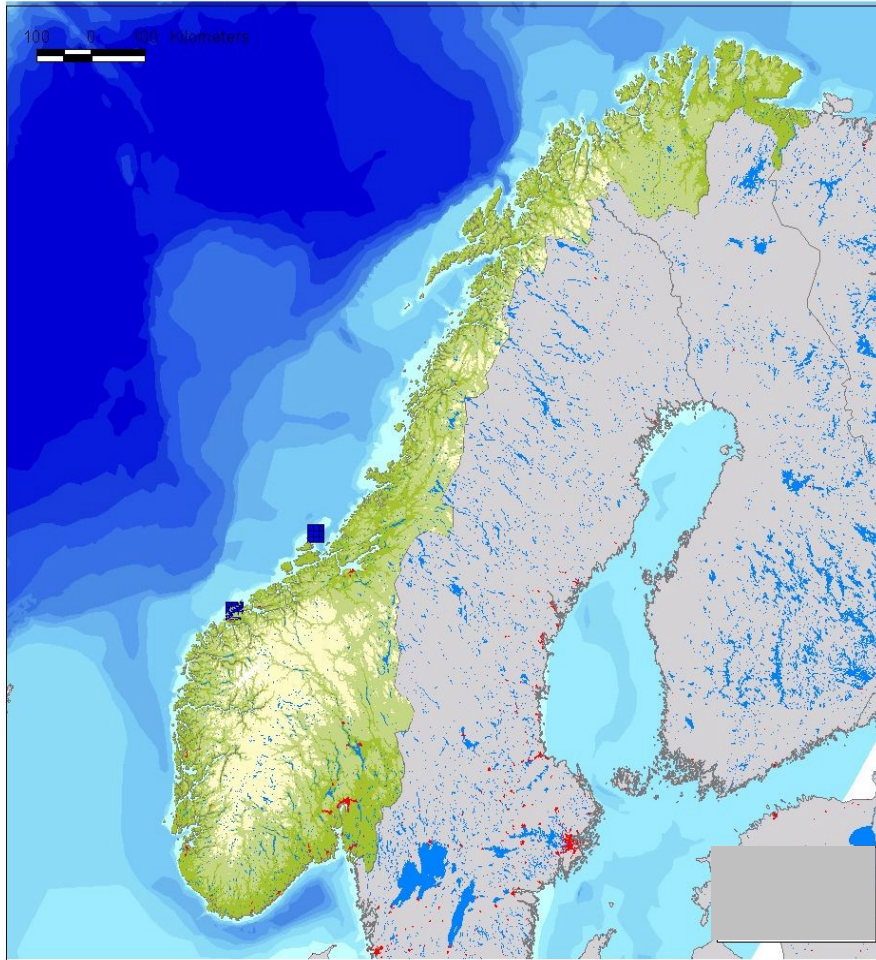
Particles, Reinjection or Discharge



Ceramic membranes



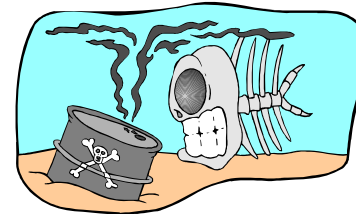
Discharge regulations - Norway



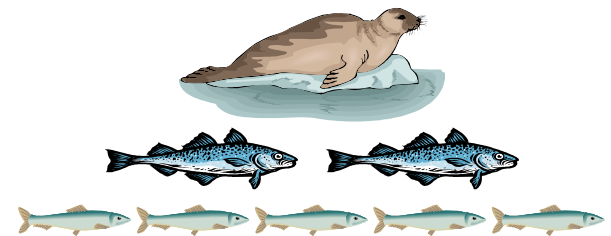
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Possible danger and threats to the environment when chemicals are used

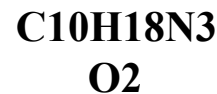
Are the chemicals toxic to marine life?



Can the chemicals accumulate in the food chain?



Are the chemicals persistent or biodegradable?



Microbial degradation



Select environmental acceptable chemicals

- Need to know all environmental test results of each component in the chemical (HOCNF data sheet)
- Material safety data sheet (MSDS) does not give enough environmental information

ACUTE TOXICITY



Turbot Fish



Corophium v.
Sediment reworker



Skeletonema c.
algae



Acartia tonsa

BIOACCUMULATION POTENTIAL



Partition octanol-water

or



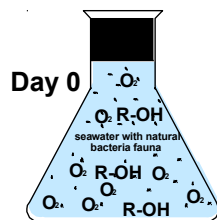
HPLC



$$\text{Log } \frac{\text{partition in octanol}}{\text{partition in water}}$$

Log Pow

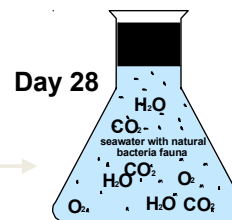
BIODEGRADATION



CHEMICAL + OXYGEN

Biodegradation

OECD 306 sea water test



CARBONDIOXIDE + WATER + S + P + O + N....



**Job
done**

What's in the barrel?

Clean water



HOPE FOR THE FUTURE?

Lots of energy in hope

**Proper HC management
needs knowledge**

become

Water&Health agents



No Platform?



Our **BLUE** Planet **in trouble**



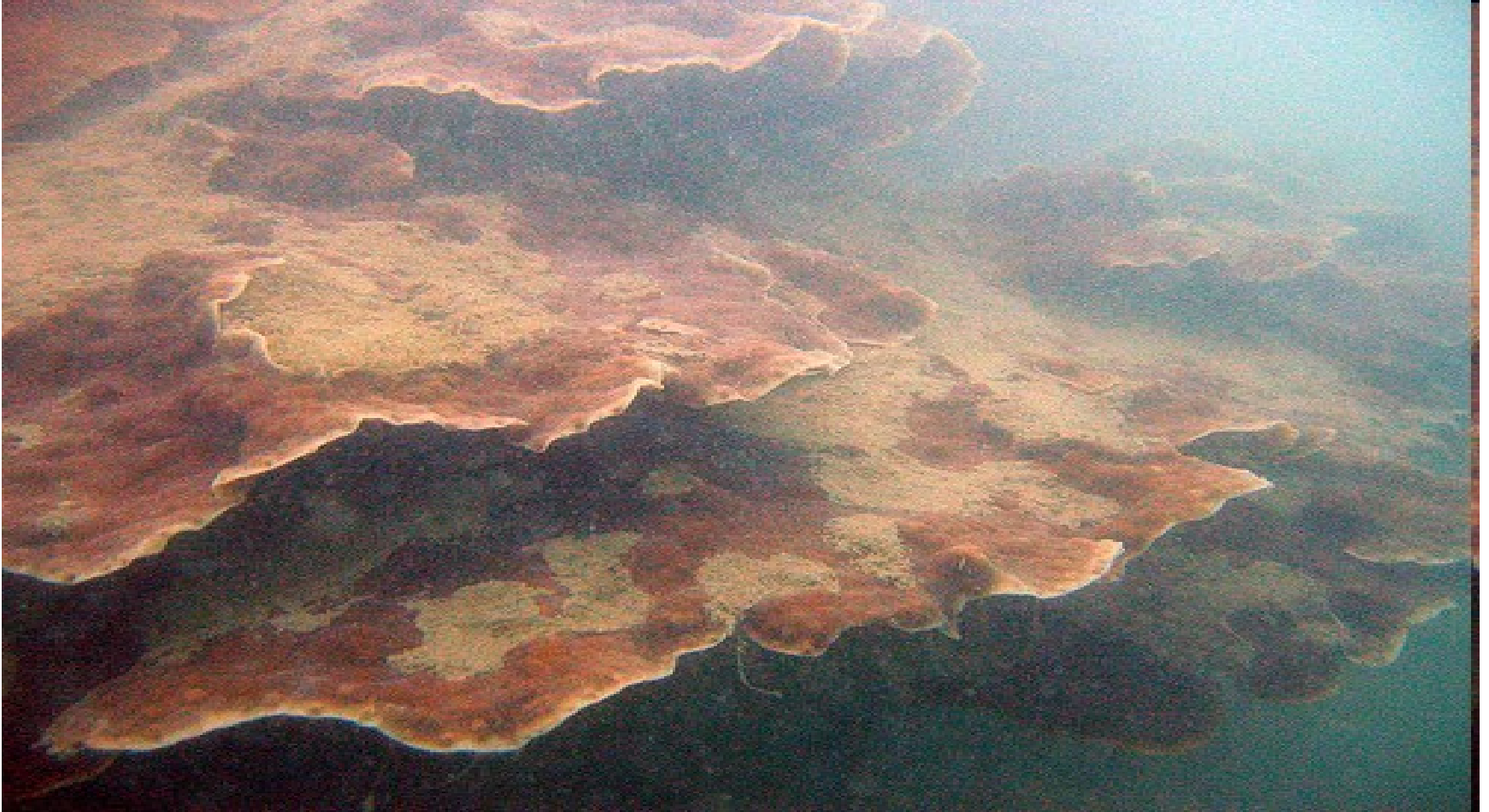
Where is the future

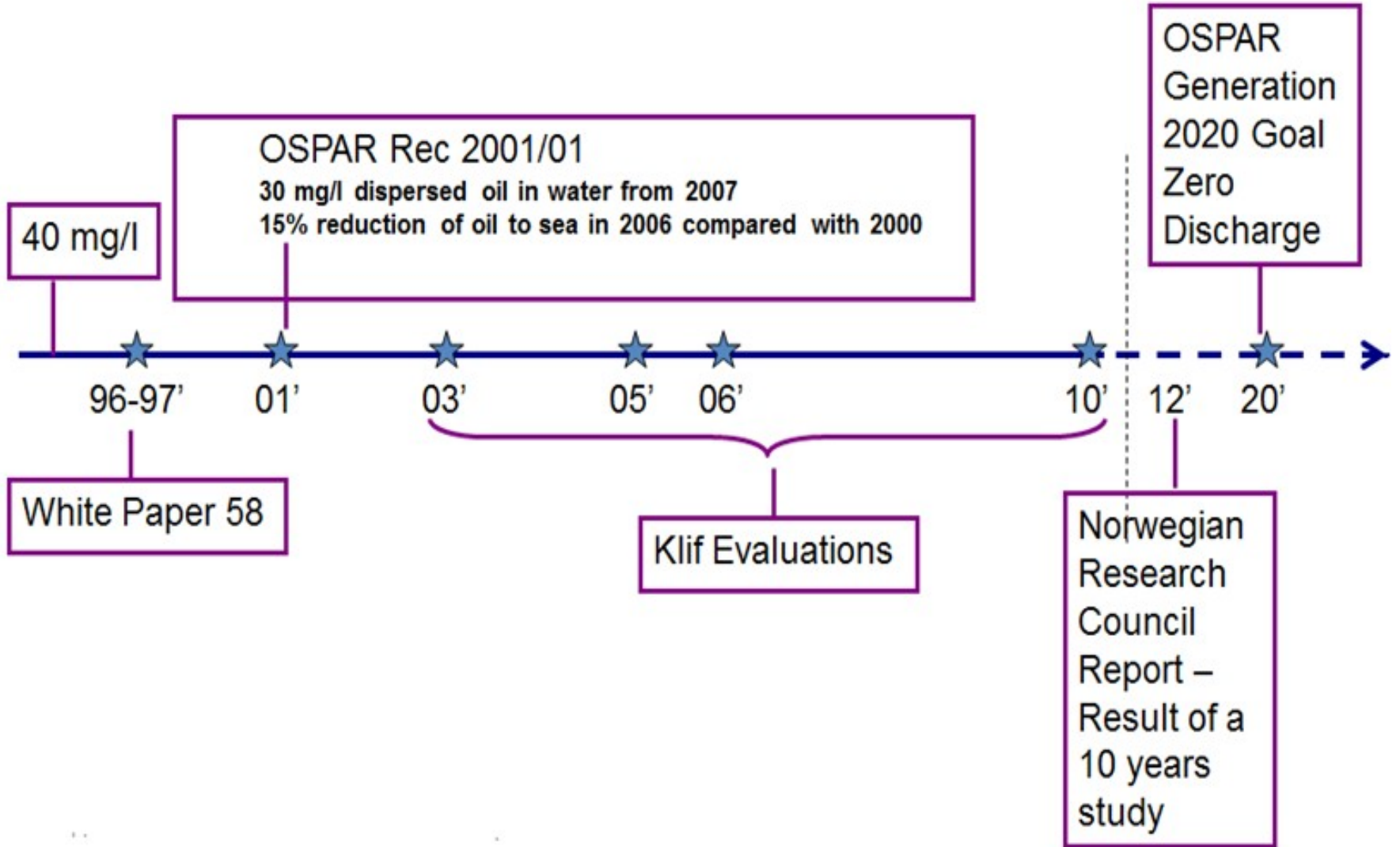


Corals & water



No light → **No algae**
warm & **CO₂** water (pH) →
No corals





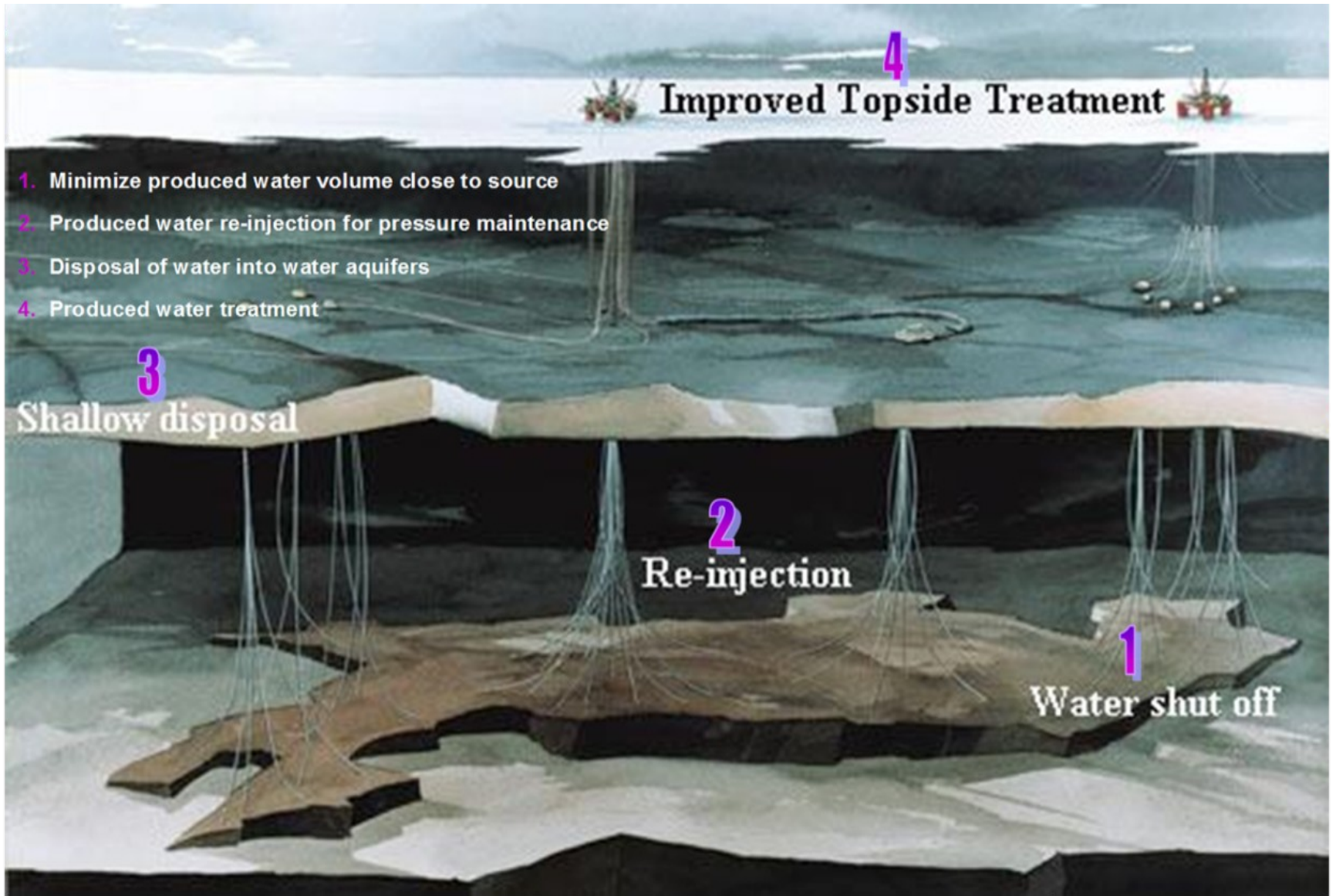
4 Improved Topside Treatment

1. Minimize produced water volume close to source
2. Produced water re-injection for pressure maintenance
3. Disposal of water into water aquifers
4. Produced water treatment

3 Shallow disposal

2 Re-injection

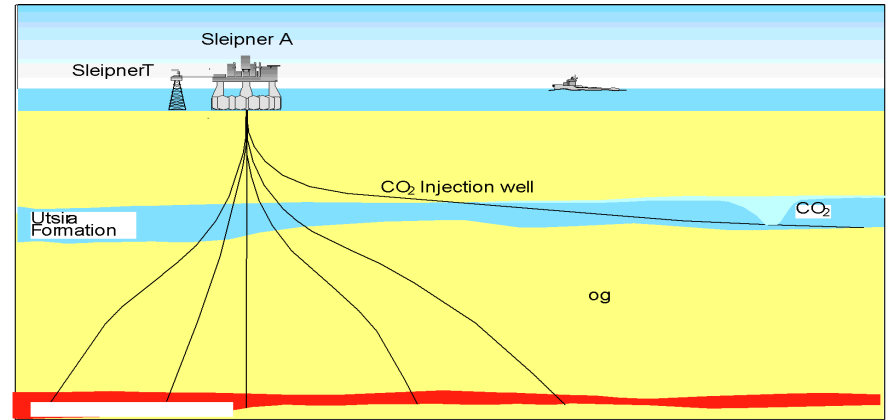
1 Water shut off



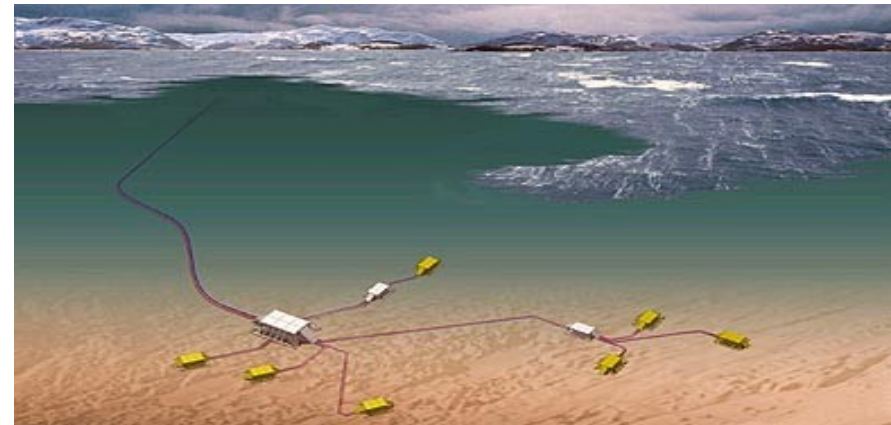
CO₂ Capture and storage (CCS) – removal of CO₂ from natural gas

- Carbon capture and storage

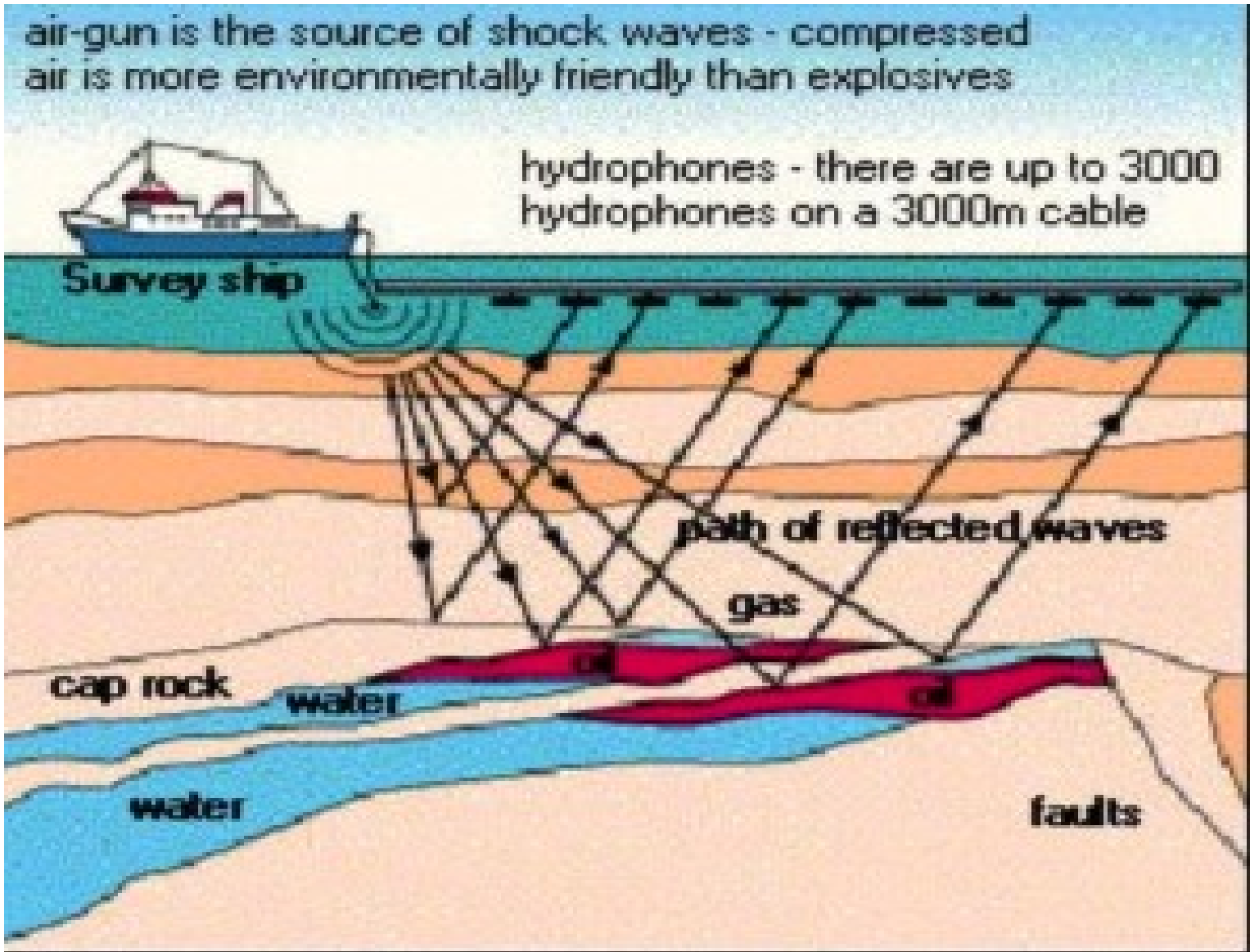
- Sleipner (1 mill ton/year)
- In operation since 1996
- Monitoring in Utsira



- Snøhvit (0.7 mill ton/year)
- In operation since 2007



Seismic research



Well activity 2012 - Scandinavia

NORWAY

Forecast

Actuals per April 2012

EXP

DEV

EXP

DEV

62

127

10

26

DENMARK

Forecast

Actuals per April 2012

EXP

DEV

EXP

DEV

2

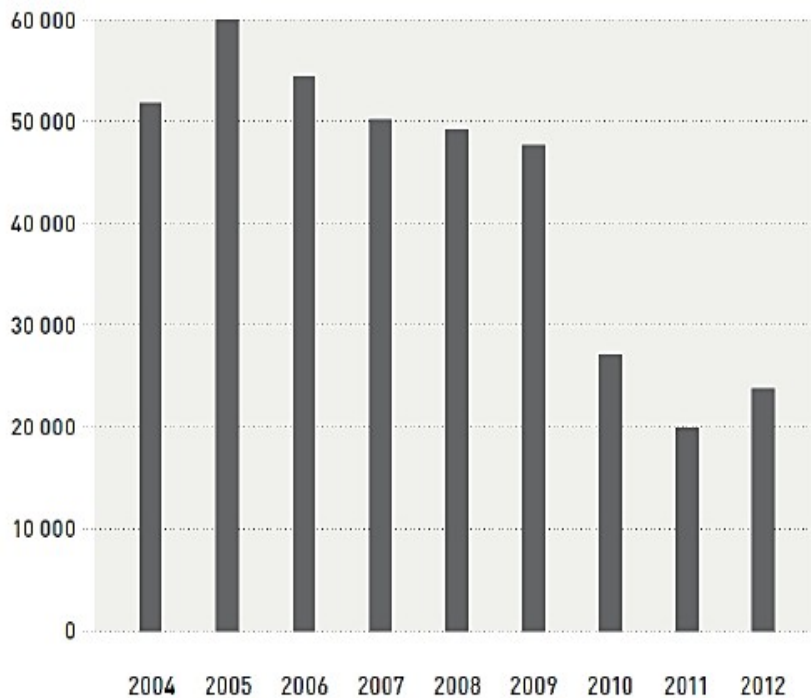
17

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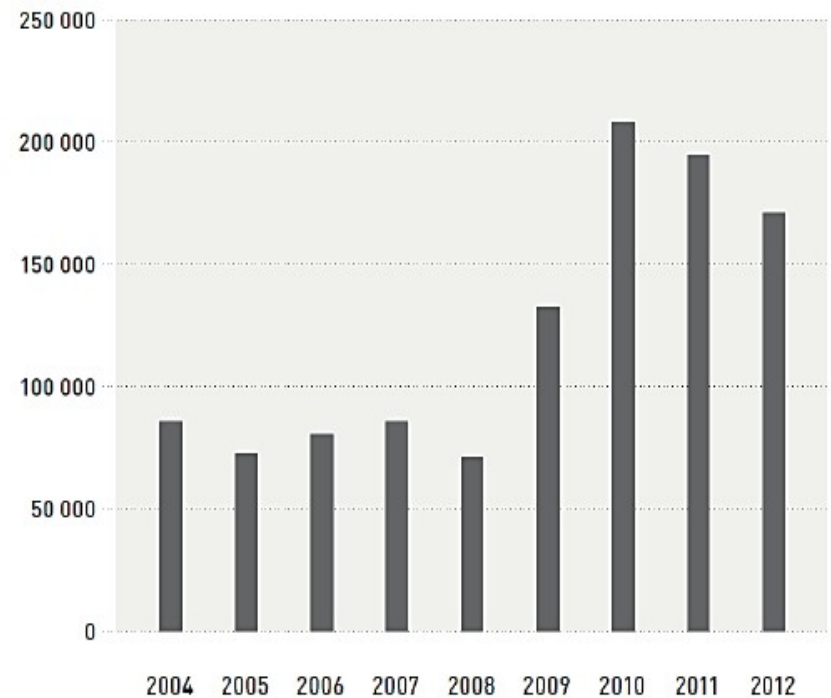
3

Drilling Waste trends 2004 – 2012

FIGUR 04 INJEKSJON AV BOREKAKS MED VEDHENG AV OLJEBASERT BOREVÆSKE (TONN)



FIGUR 05 UTSLIPP AV BOREKAKS VED BORING MED VANNBASERT BOREVÆSKE (TONN)



Hazardous Drilling Waste 2012 sent to shore from Offshore installations

314 000 mt

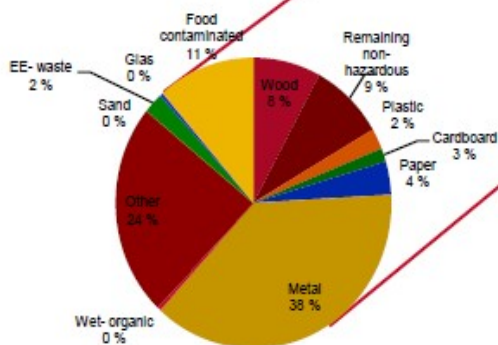
Drill cuttings and slop

88% of ALL waste

or 305 699 mt

Non-hazardous waste

8%



Other hazardous
4%