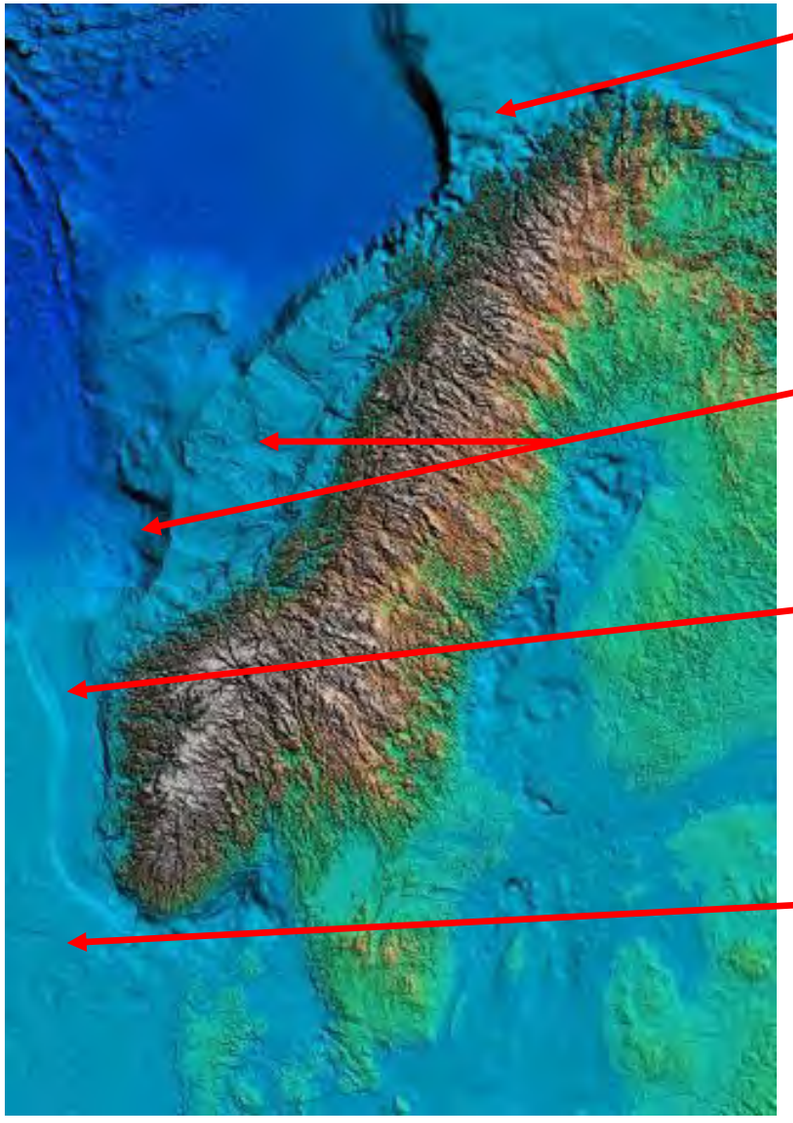
NORWEGIAN PETROLEUM
DIRECTORATE

Basin analysis: the Norwegian Continental Shelf experience

Jan Stenløkk
Norwegian Petroleum Directorate

The Norwegian Continental Shelf



Barents Sea

- proven resources mainly gas
- remotely from gas market
- less developed infrastructure
- moderate water depth (200-400m)
- environmental issues

Norwegian Sea

- mainly gas- & condensate fields
- deep water areas (300-2000m)
- environmental issues

Northern North Sea

- giant oil & gas fields
- well established infrastructure
- tail production and satellite tie ins
- moderate water depth (150-300m)

Southern North Sea

- giant oil fields (chalk)
- mature infrastructure after 40 years activity
- shallow water (70-150m)

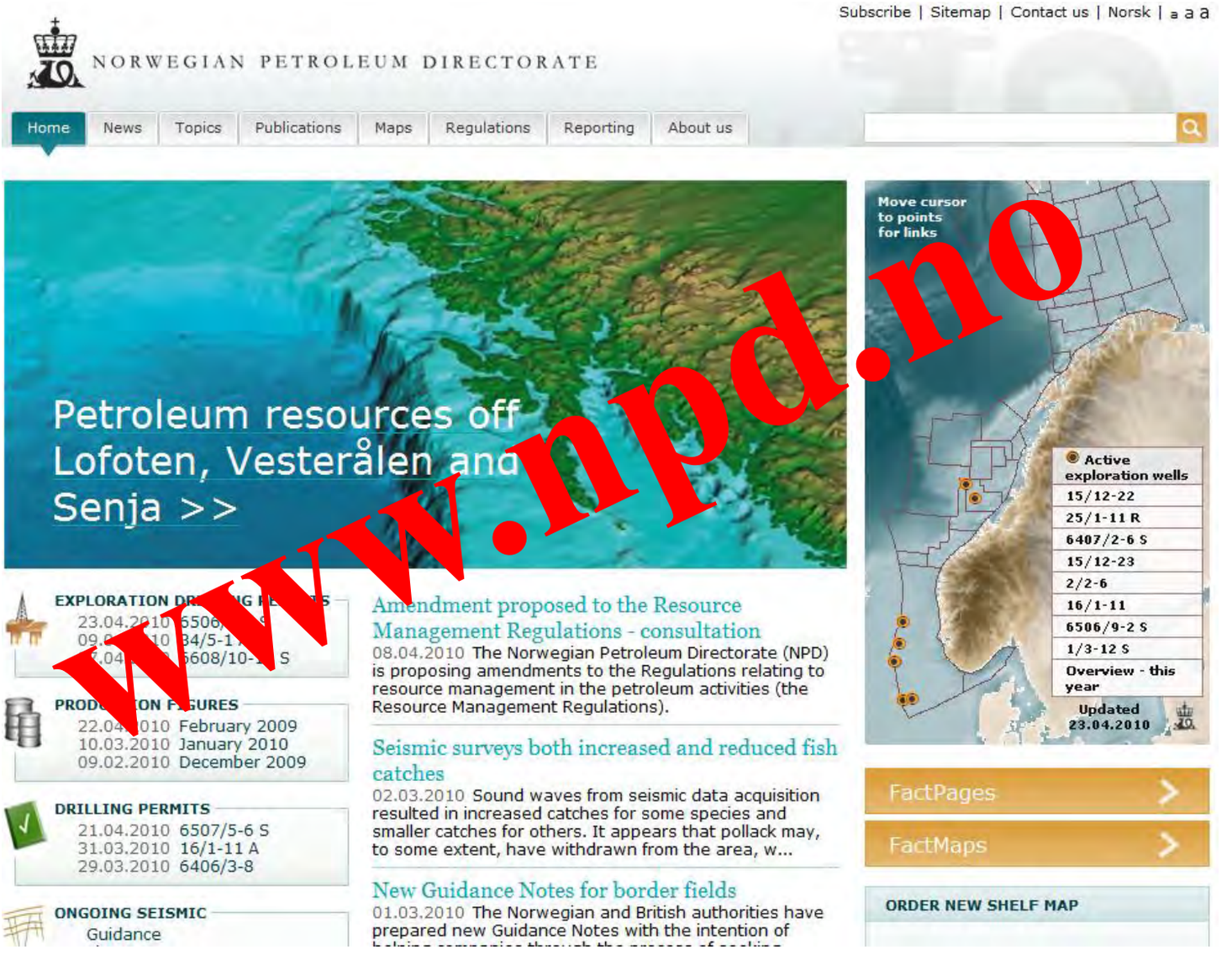
Main roles of the NPD

1. **Advisor** to the Ministry
2. **Overview** of facts and communicate facts
3. **Promote** realisation of full resource-potential
4. **Develop framework and execute**
5. **Follow-up** activity
6. **Facilitate** efficient industry processes

Purposes of prospect evaluation by NPD

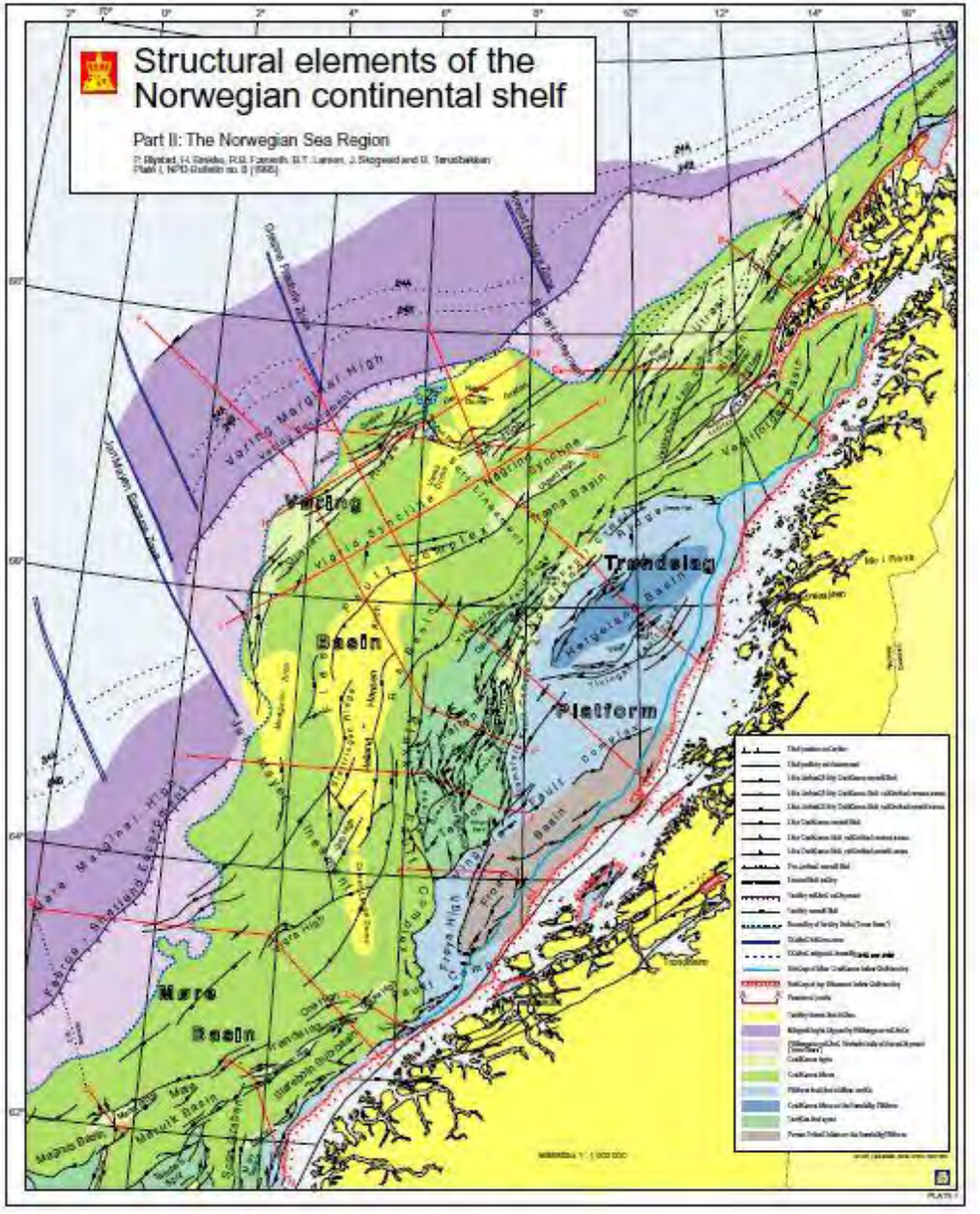
- Basis for recommendation for which blocks should be awarded and proposals for work commitment for licenses
- Basis for evaluation of applications for licenses or bidding rounds
- A state participation can be decided on basis of the evaluation carried out by the government in addition to the applicants/bidders

NPD public and free released material

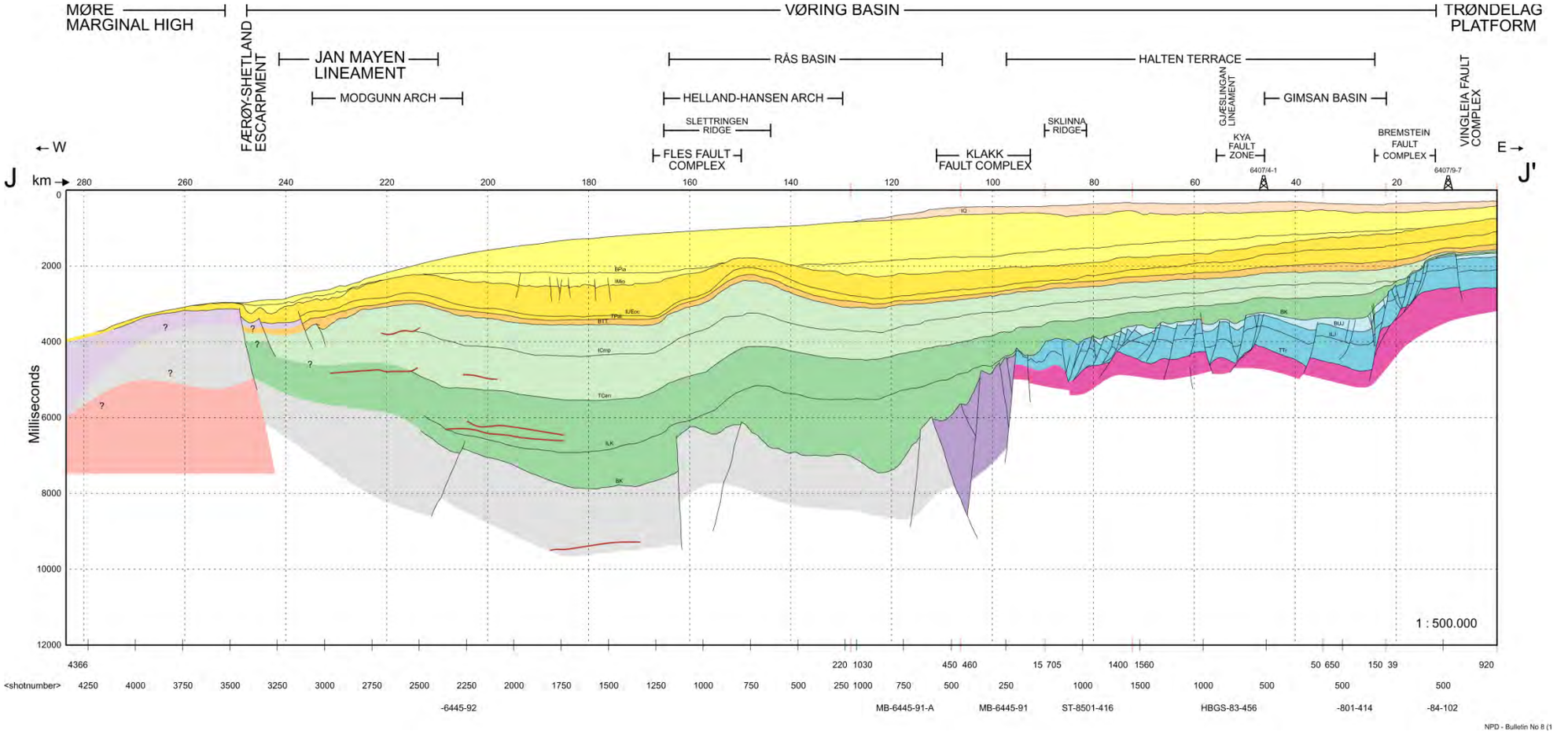


www.npd.no

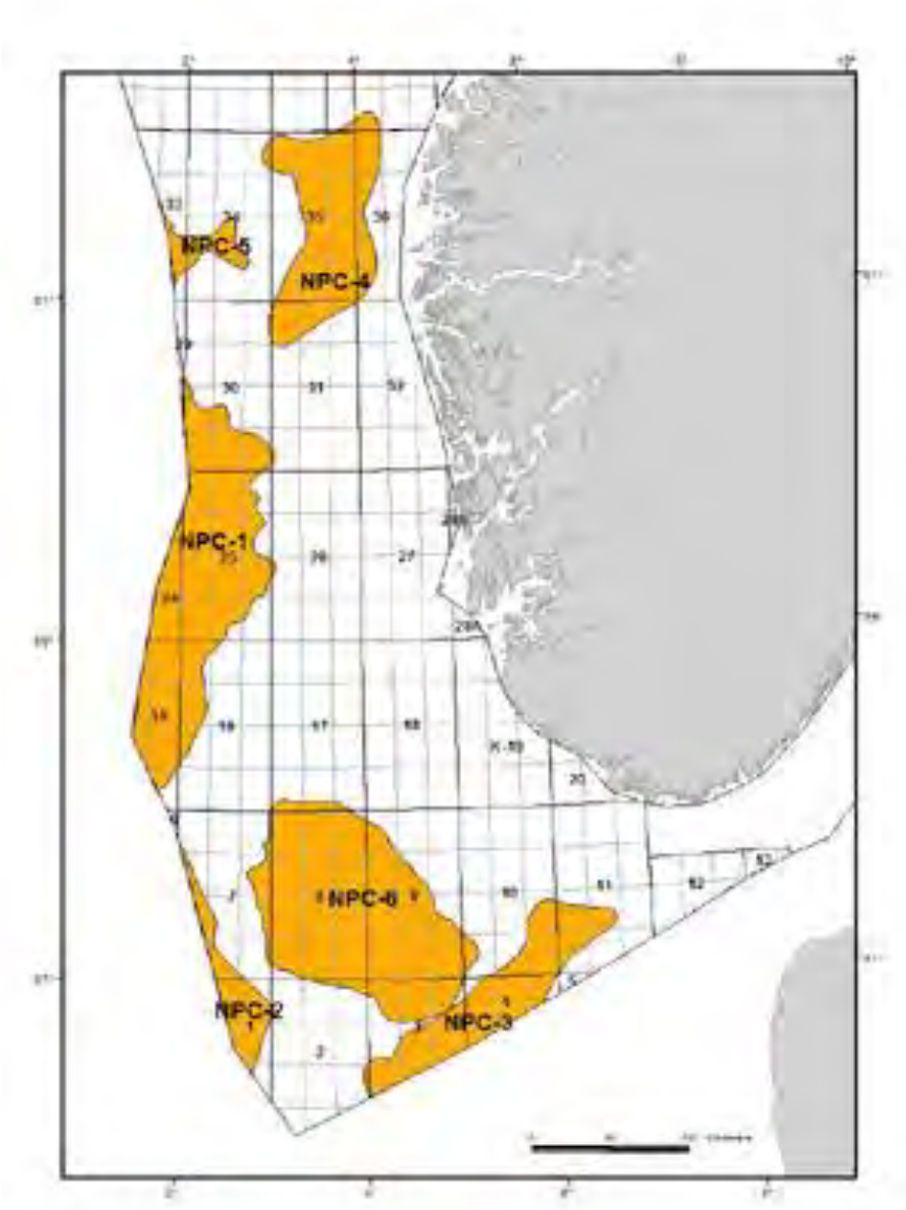
Main structural elements

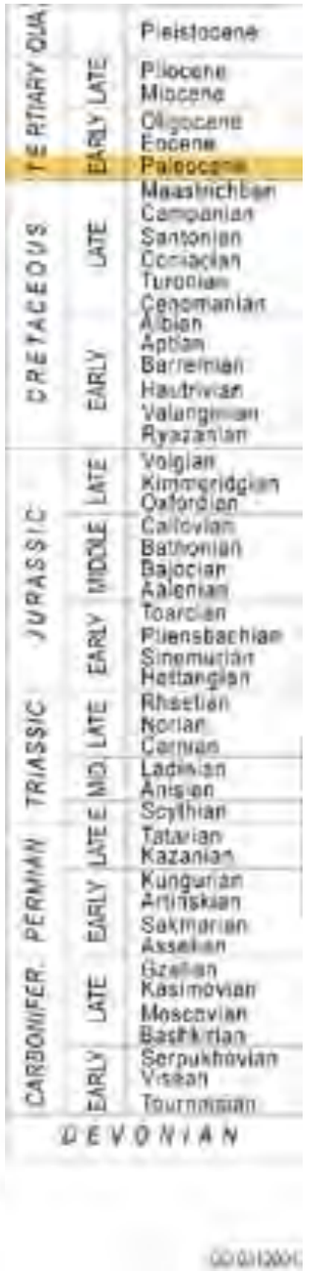


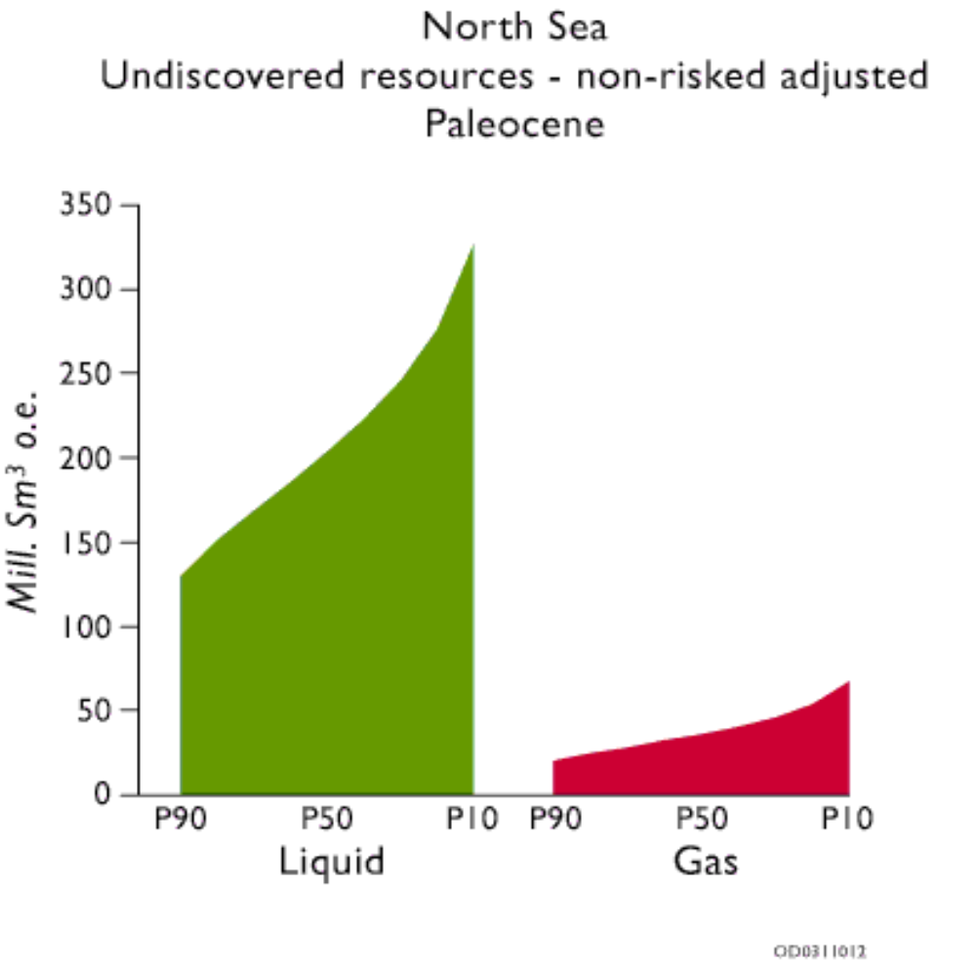
Haltenbanken - NPD



Exploration model for Tertiary







Request for geochemical data and samples

OLJEDIREKTORATET
NORWEGIAN PETROLEUM DIRECTORATE

The NPD's Fact-pages

Home | Feedback

How to obtain core, cuttings, oil samples and geochemical standards from the NPD

The NPD core store houses cuttings and conventional cores (no sidewall cores) from over 1000 wells on the Norwegian continental shelf. In addition, the Norwegian Geochemical Standard and more than 600 DST samples are stored.

Applications for core, cuttings and oil samples must contain:

A complete description of the investigation:

- Objectives (Why are you undertaking this study?)
- Methods (How are you going to achieve your objectives?)
- Time frame (preferred sampling date, project milestones, completion date)
- Distribution of results (journal article, thesis, non-exclusive report etc.)

Wells, intervals, sample type and amounts:

For example,

Well	Interval(m)	Sample type	Spacing	Amount
1/2-3	1200 - 1350 m	cuttings	apprx 15m	35 g
4/5-6	1950 - 2000 m	cores	apprx 5 m	20 g
7/8-9	2750 - 2800 m	oil	-	2 ml

Note: The entire project report for all studies carried out on NPD core and cuttings samples, must be given to the NPD upon project completion. This applies also for studies based only partially on NPD material. In addition, all thin sections, micropaleontological and palynological slides produced from NPD material, must be delivered to the NPD upon project completion.

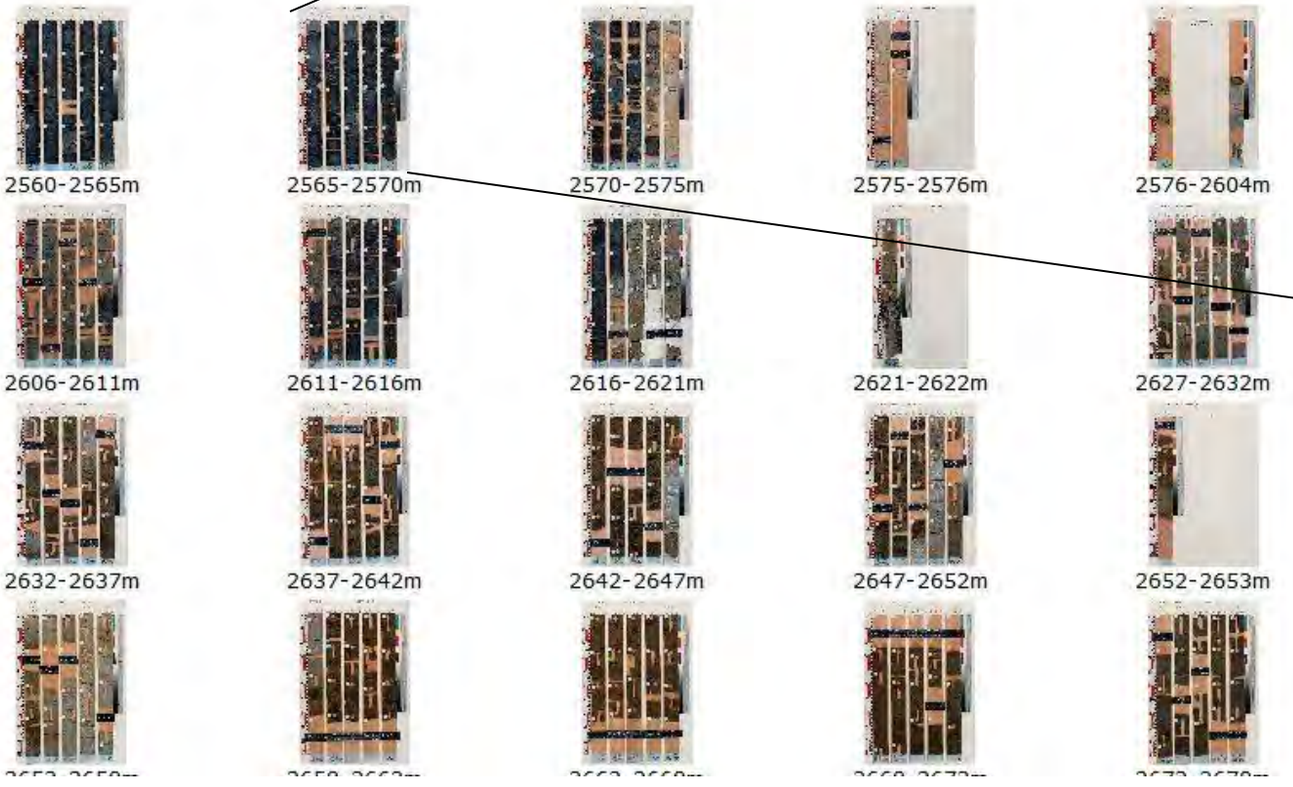
Applications for Norwegian Geochemical Standard (NGS) samples must contain:

- Applicant's name, postal address, telephone and fax number, e-mail address, and a contact person.
- Description of the normal analytical activity of the laboratory (e.g. service laboratory for the oil industry, university laboratory working with environmental/geochemical problems, etc).

NPD core data and photos

Core number	Interval
1	2560-2576.40
2	2576.40-2604
3	2604-2605
4	2618-2622
5	2627-2652.74
6	2653-2680.07
7	2680.07-2702
8	2702.96-2704
9	2705-2710.64
10	2710.64-2738
11	2738.64-2765

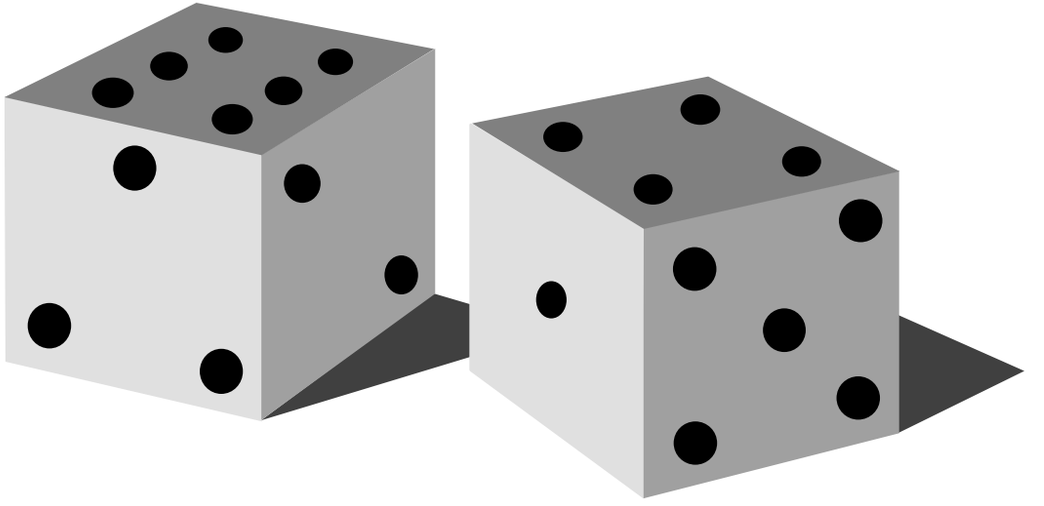
Scanned core photos



To make a discovery...

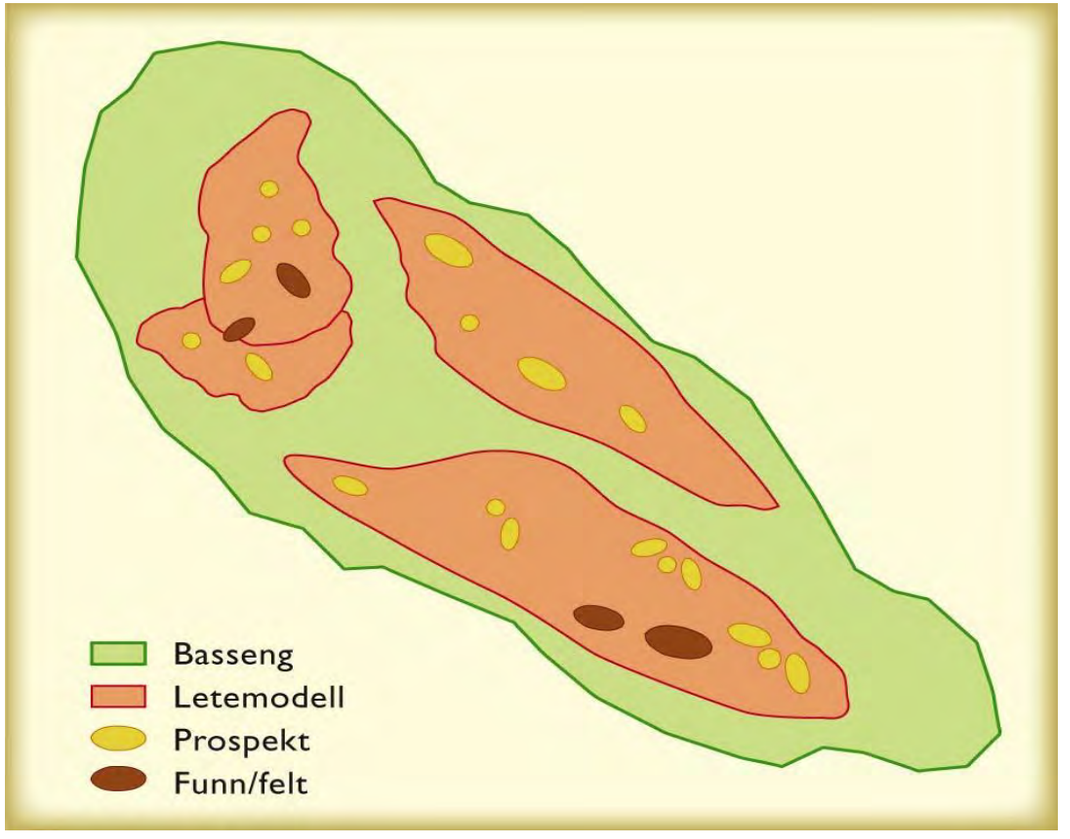
Play or prospect related probabilities:

- **Reservoir**
- **Porosity**
- **Correct mapping**
- **Trap definition**
- **Mature source rock**
- **Migration into the trap**
- **Retention of HC in the trap**

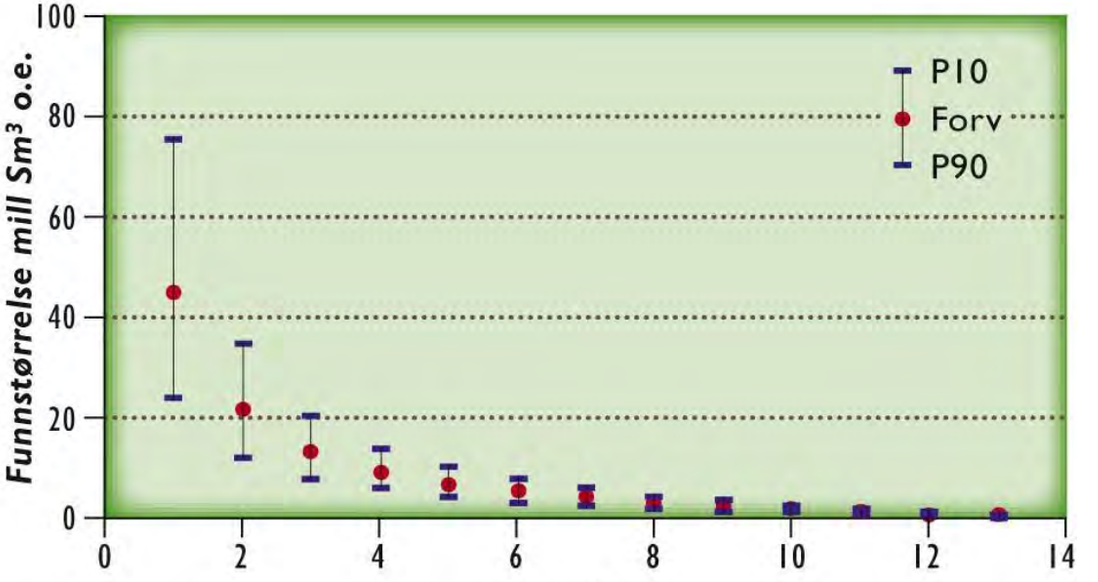


Exploration models and volumes

Basin, prospect and and plays



Statistics of basin plays

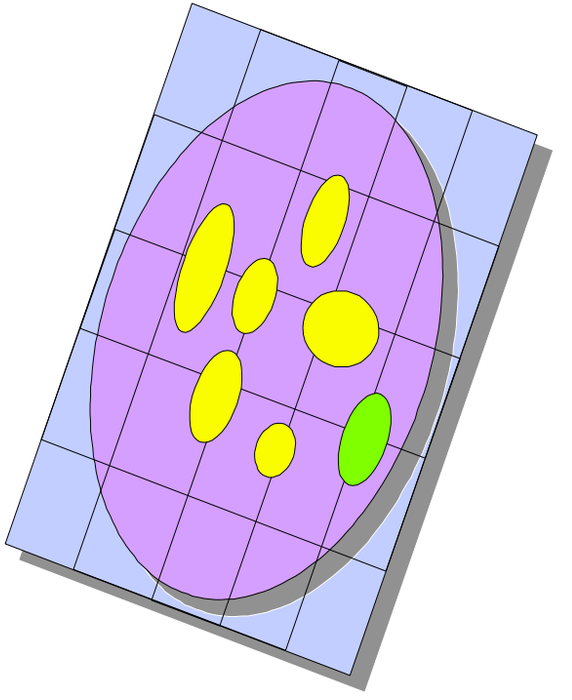


A basin contain exploation models with prospects and plays

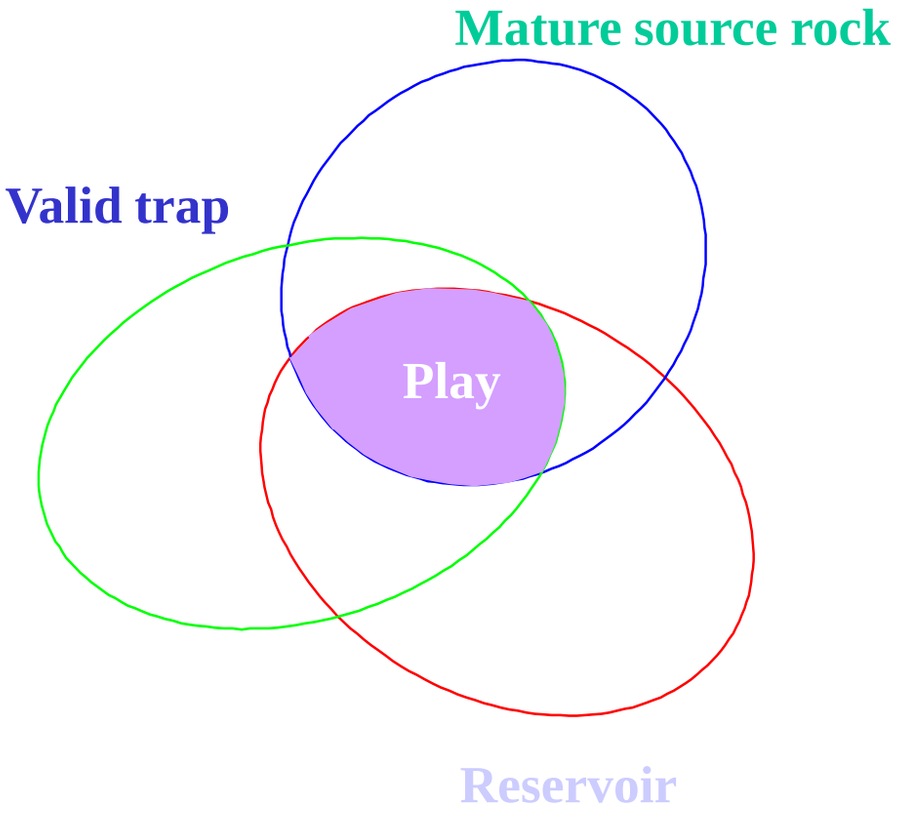
Play analysis

A group of prospects within a geographical limited area, which are defined by a common set of geological factors (efficient source rock, reservoir, trap type and seal).

* **Confirmed plays; proved hydrocarbons**
* **Unconfirmed plays; has not yet proved hydrocarbons**



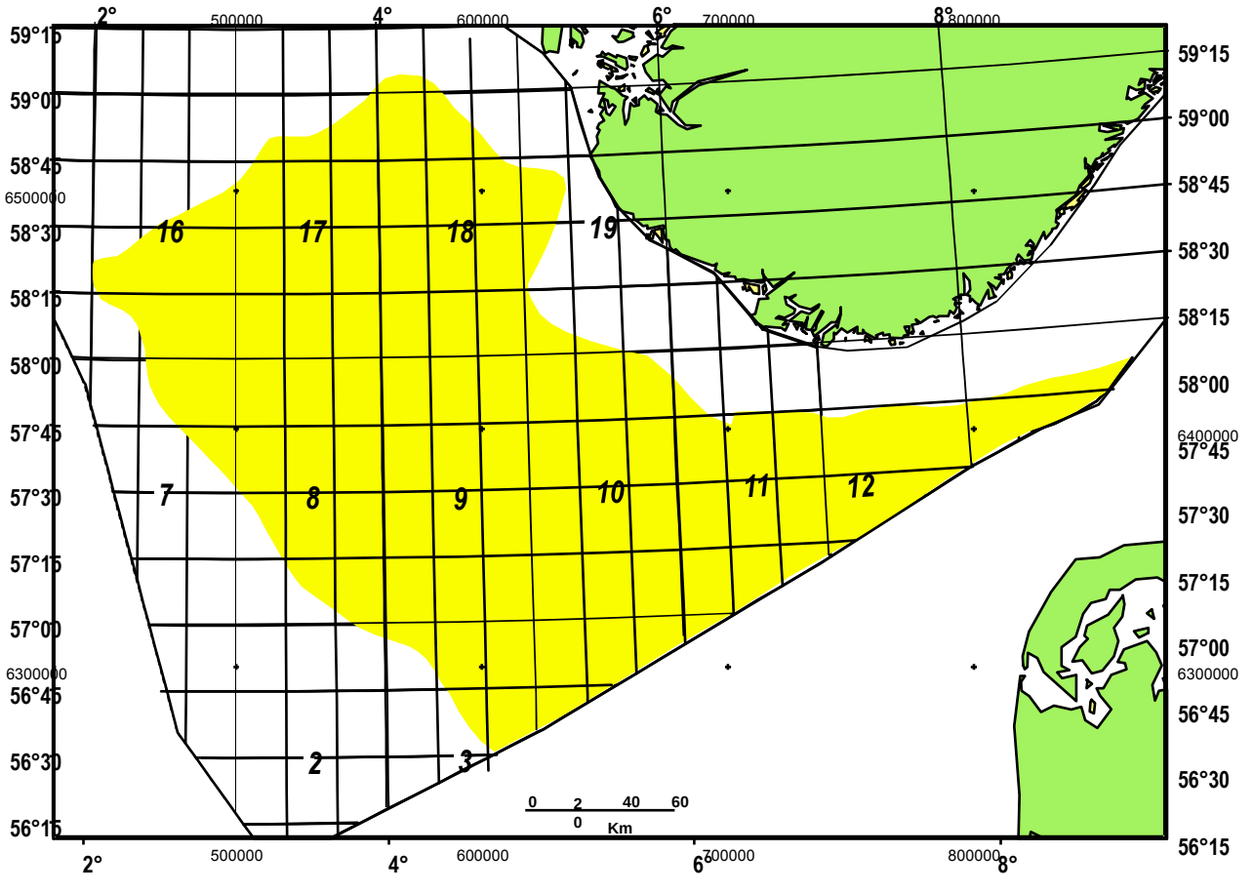
Play definition



Play criteria:

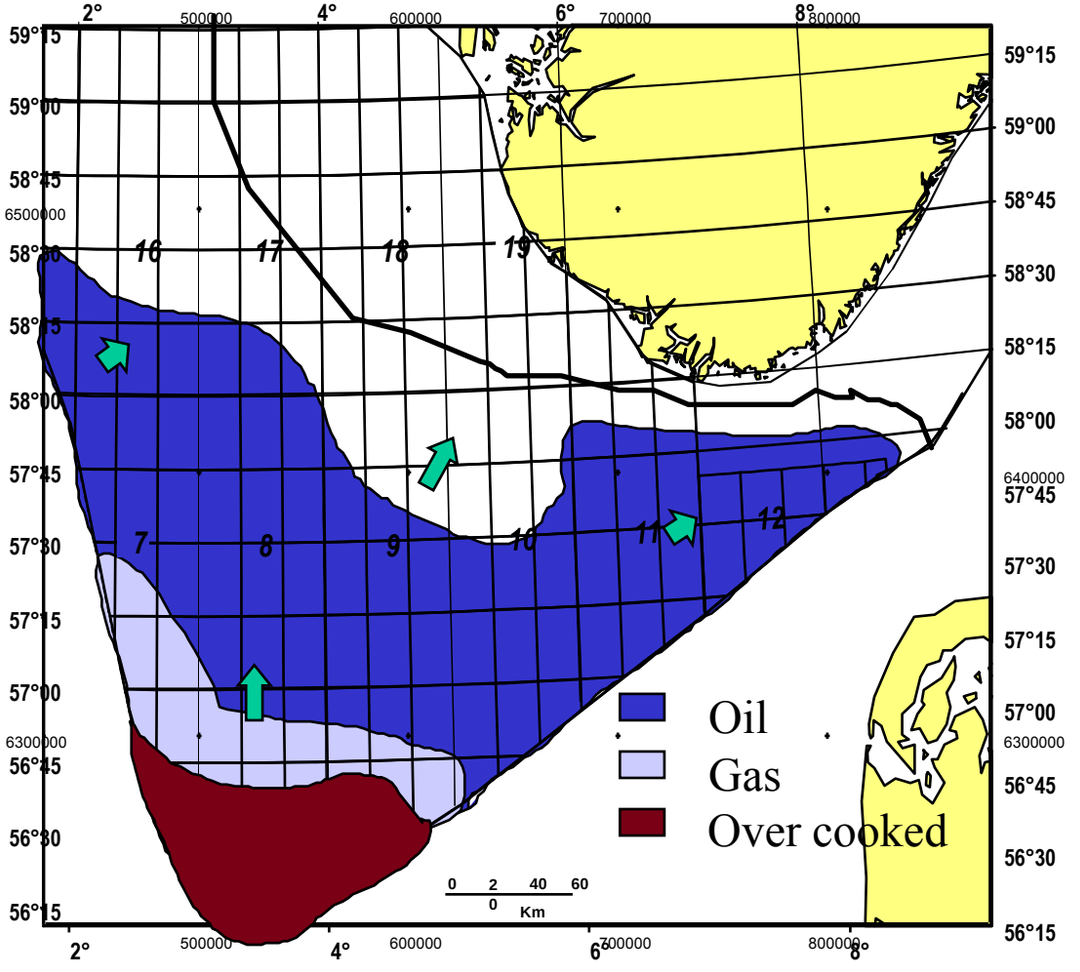
- Reservoir
- Mature source rock
- Migration
- Valid trap

Pre Jurassic reservoirs in the North Sea



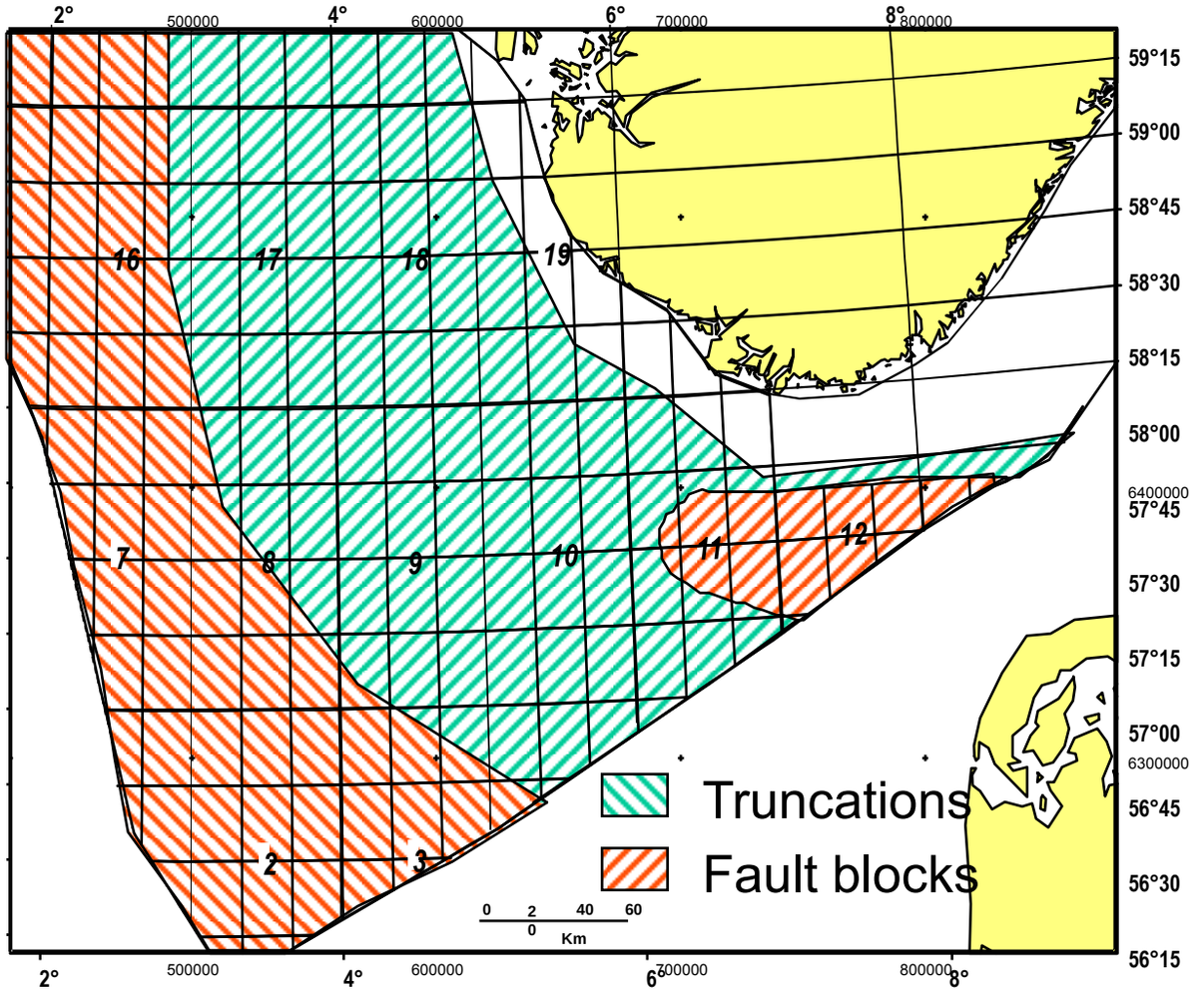
- depth
- diagenesis
- porosity
- cementation
- facies changes

Maturity map



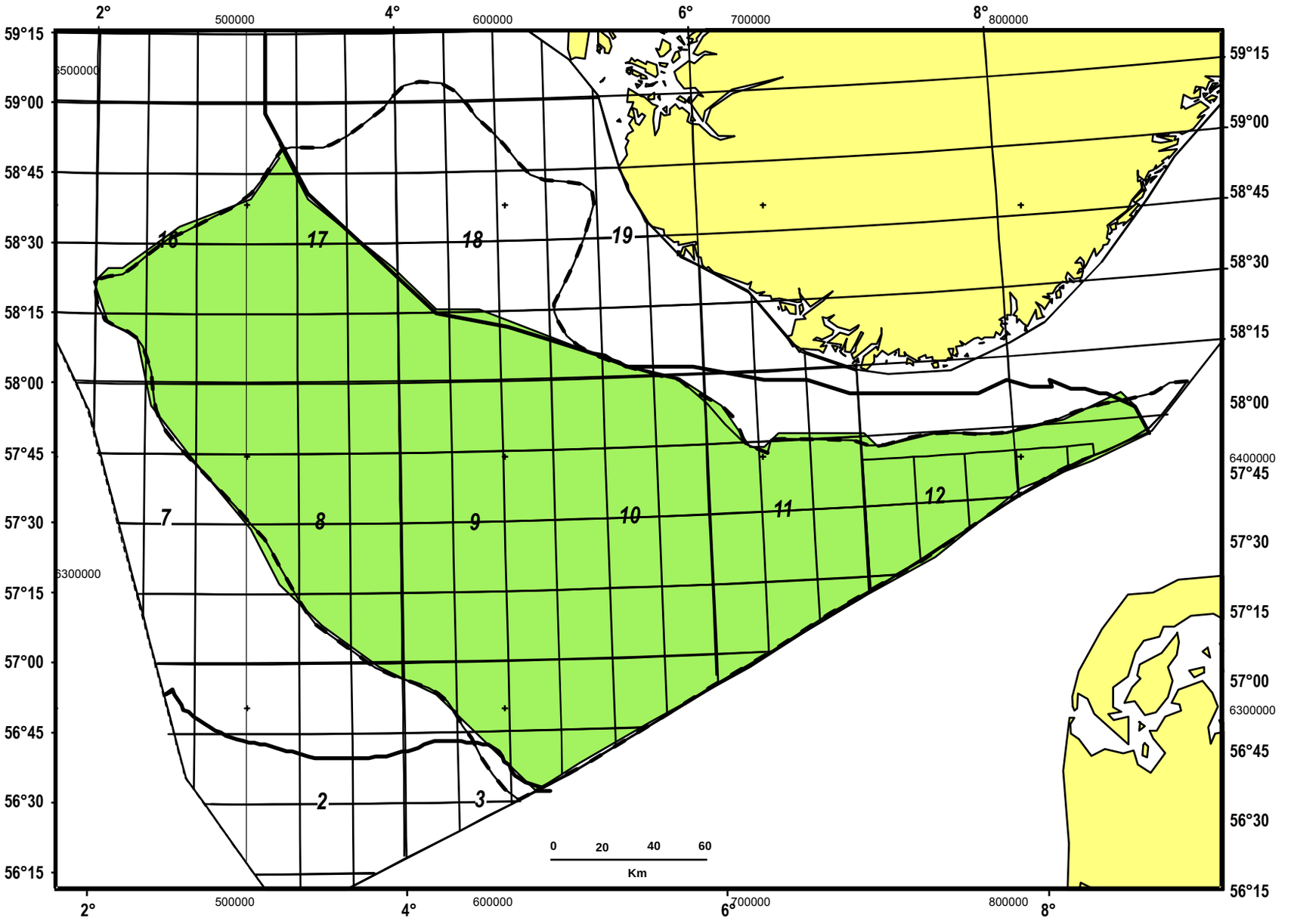
- maturity
- volume
- migration routes
- timing

Trap map, Pre Jurassic play

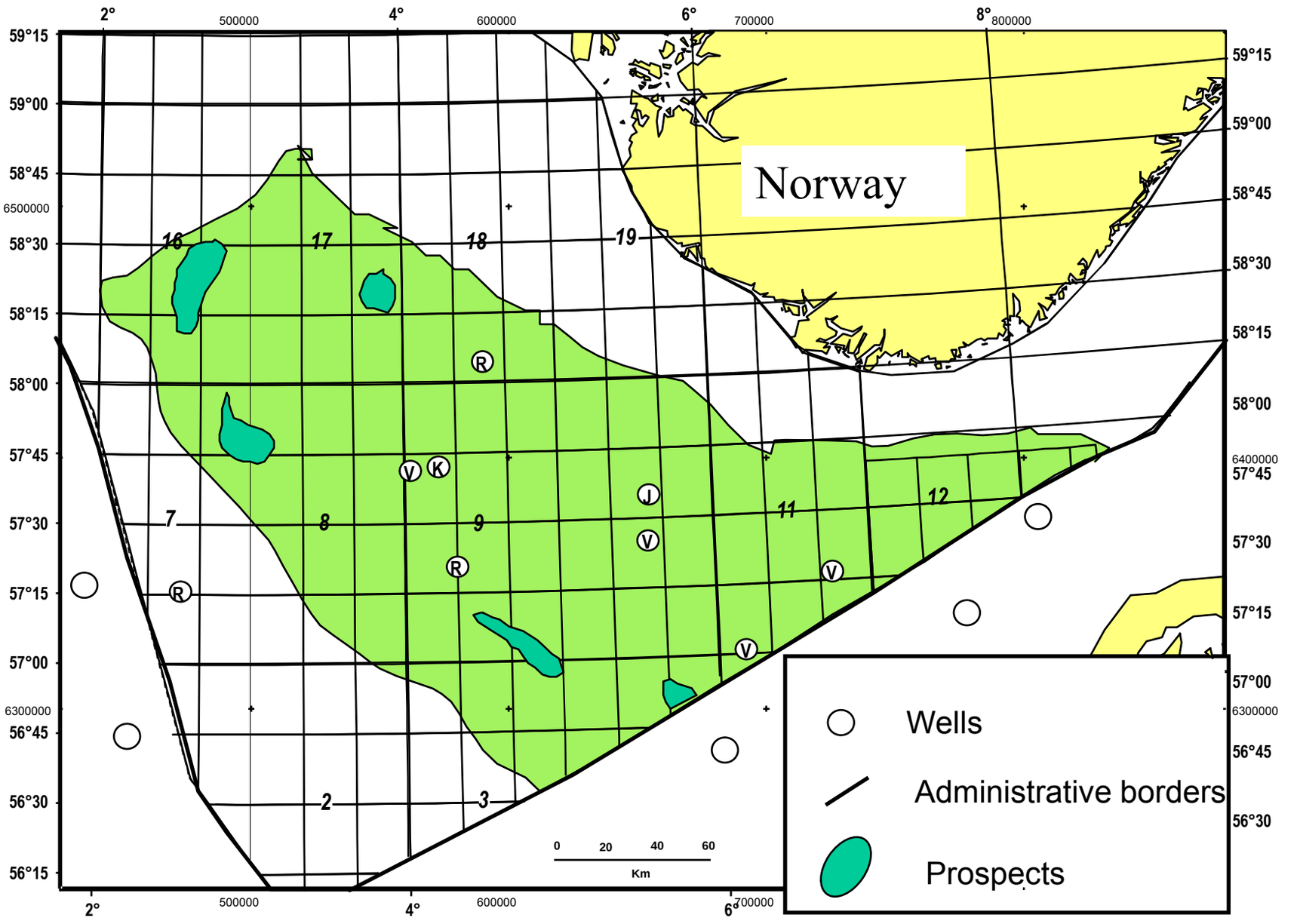


- Structural traps, variation in tectonic impact
- Stratigraphic traps, variations in depositional model
- Changes in seal potential
- Retention potential; HC phase and late uplift or tilting

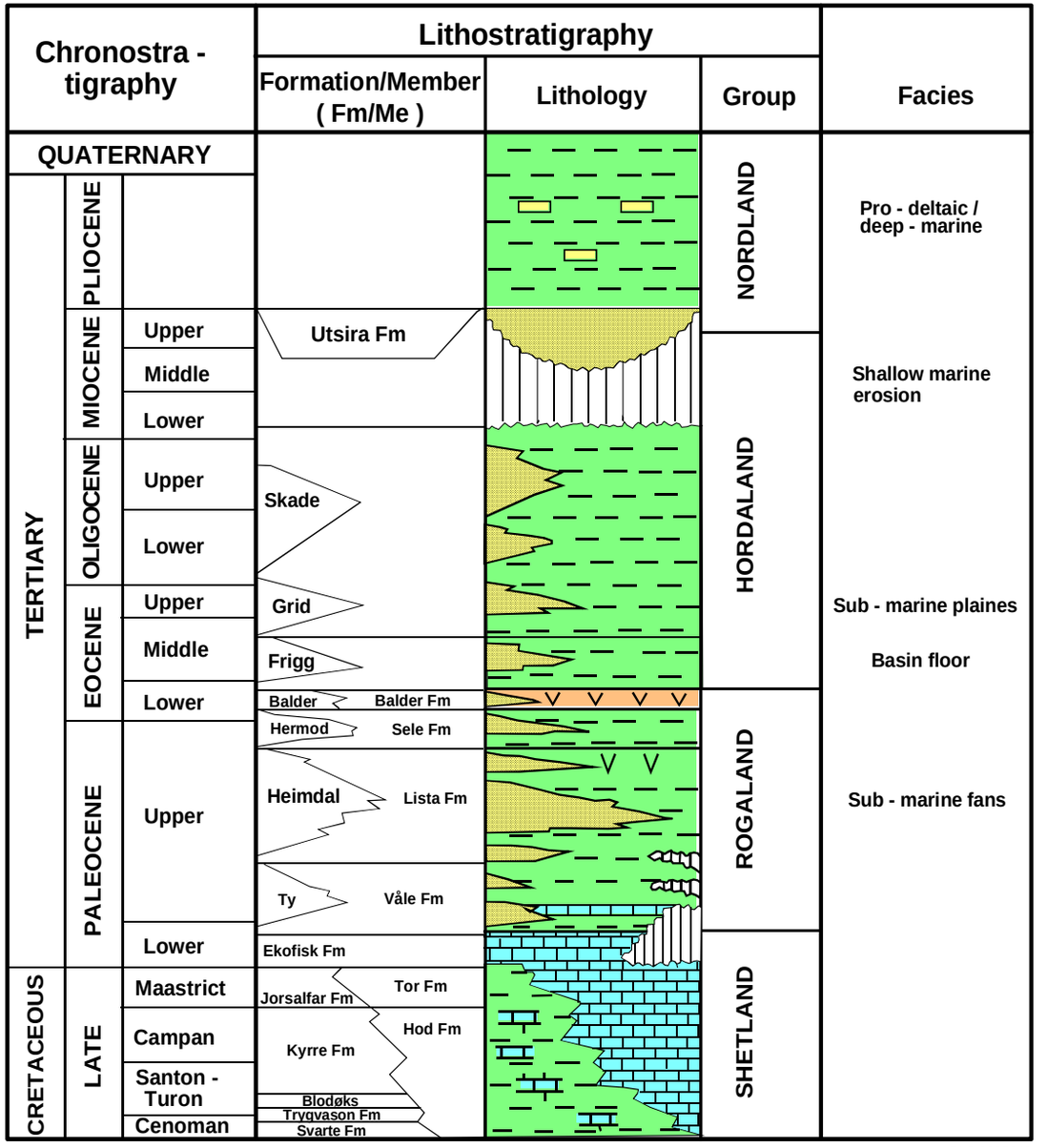
Pre Jurassic play map

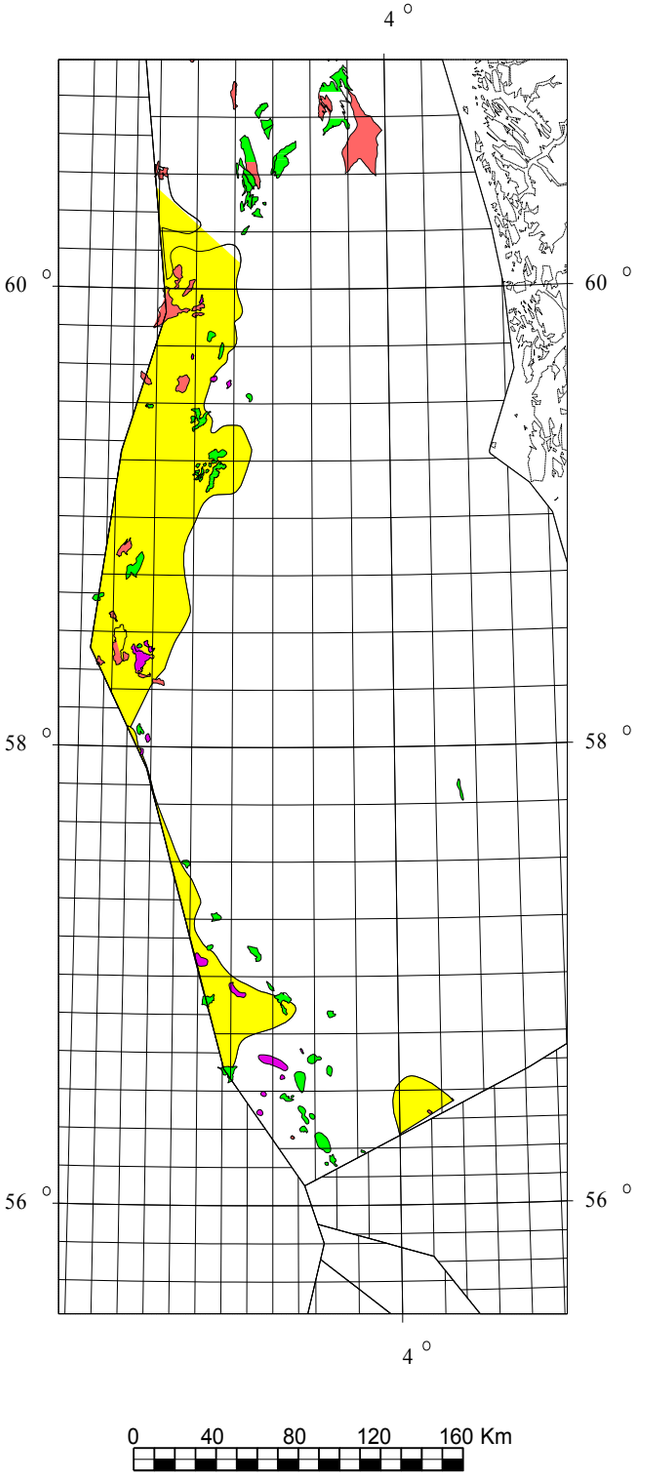


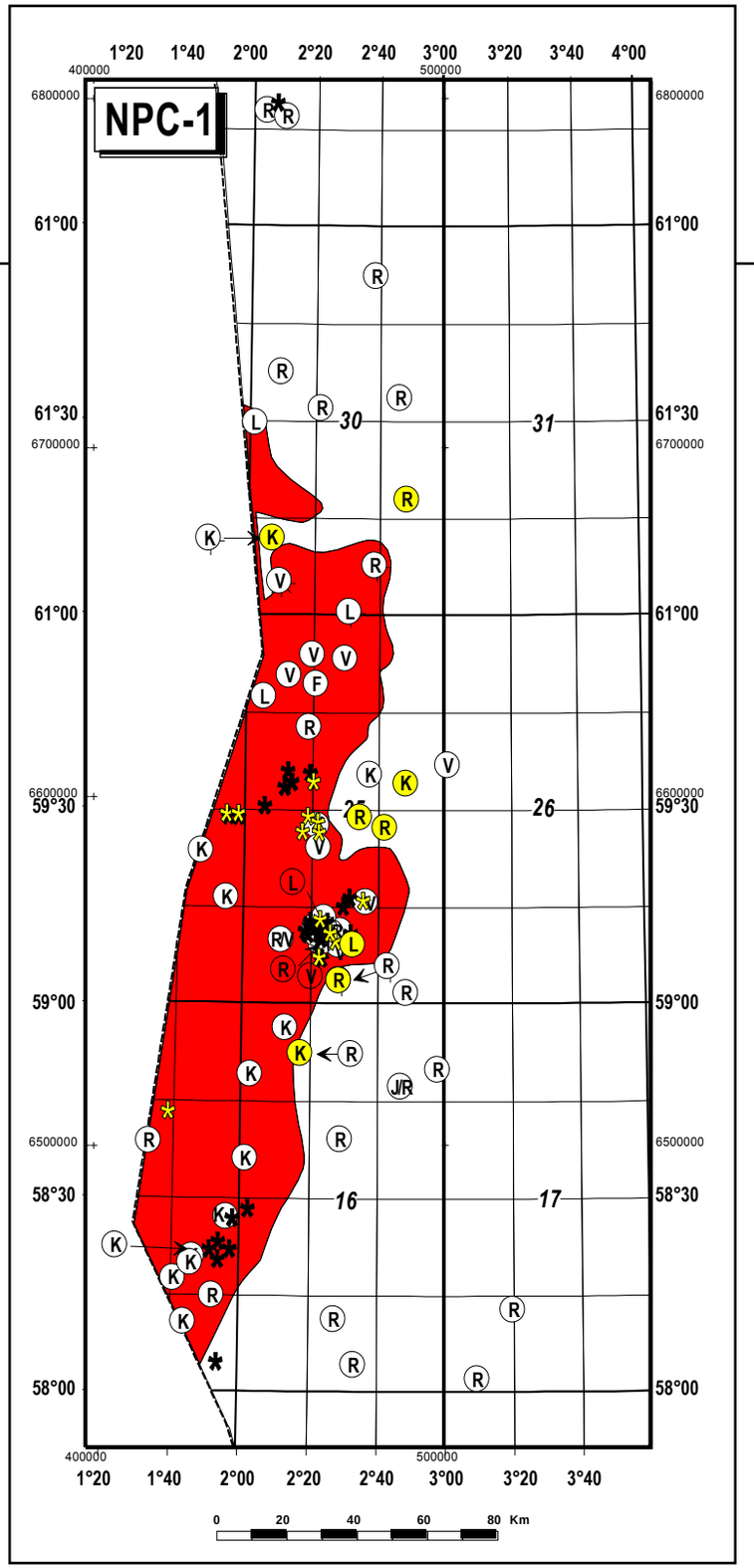
Experience map



North Sea: Paleocene Play







Experience Map

NPD

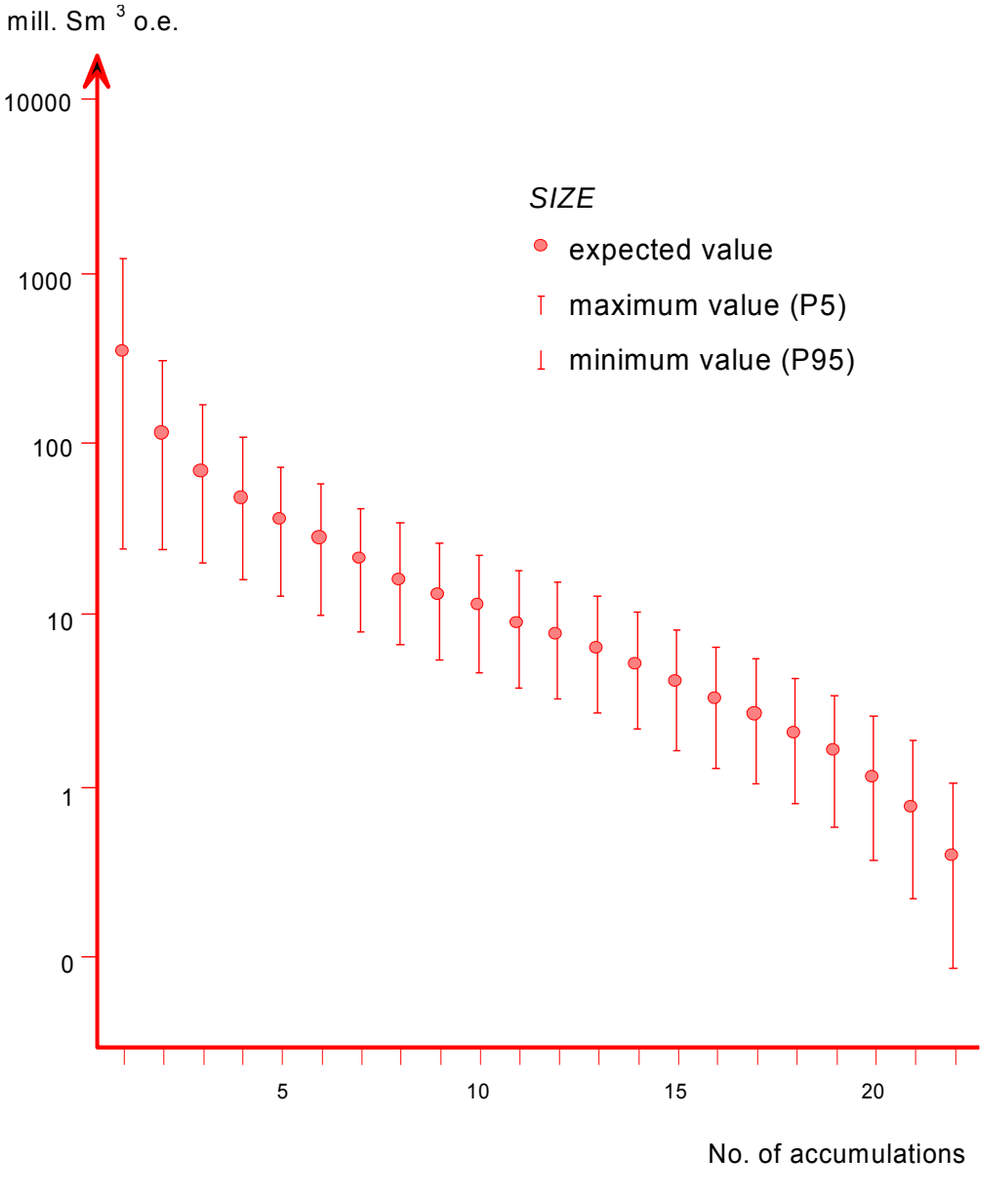
* **Success** (wildcat and appraisal wells)

o **Dry well**

Problem Legend

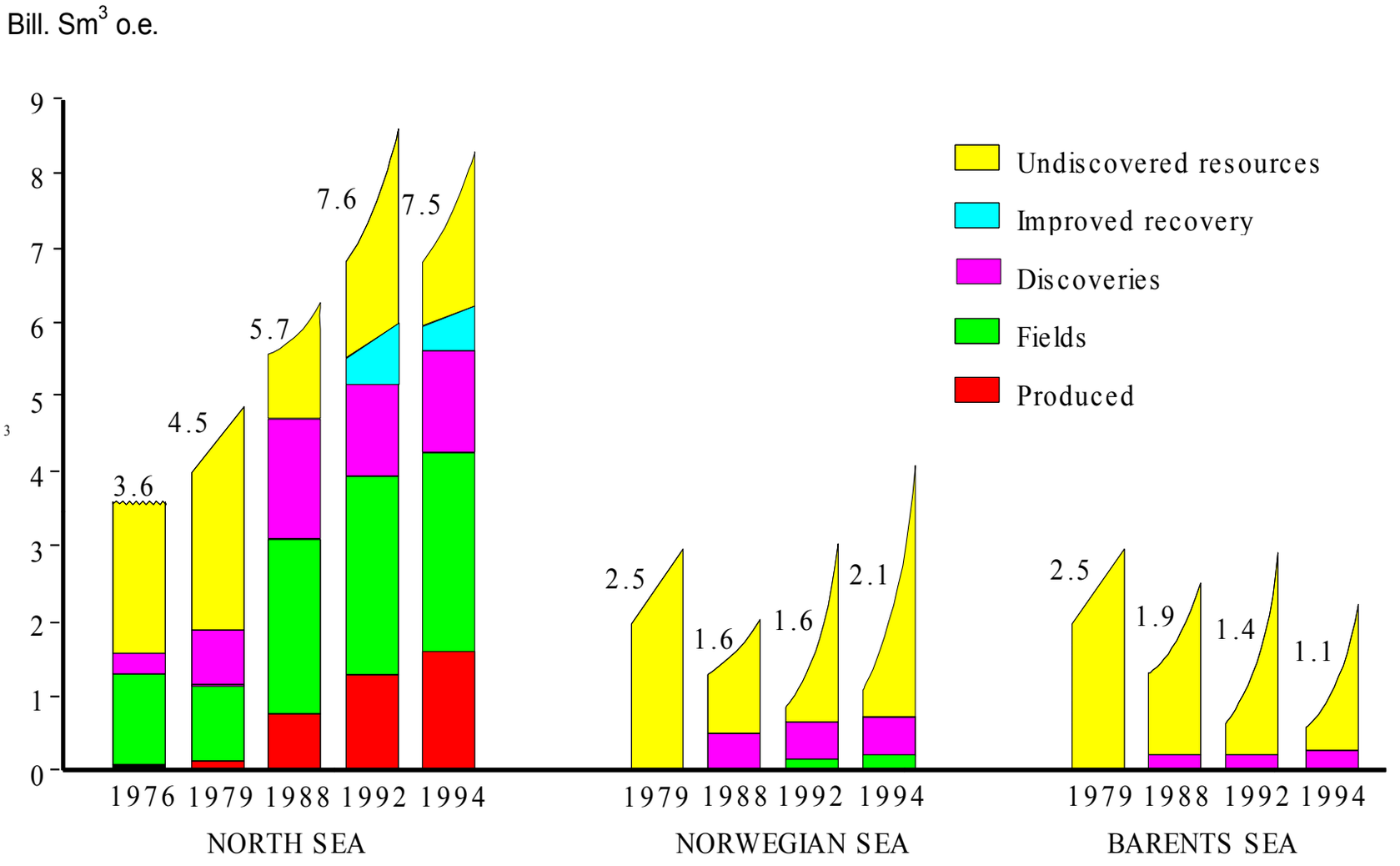
- R lack of reservoir
- K source / migration
- F seal (vert. or lat.)
- L outside trap
- V other

Estimated future discovery sizes

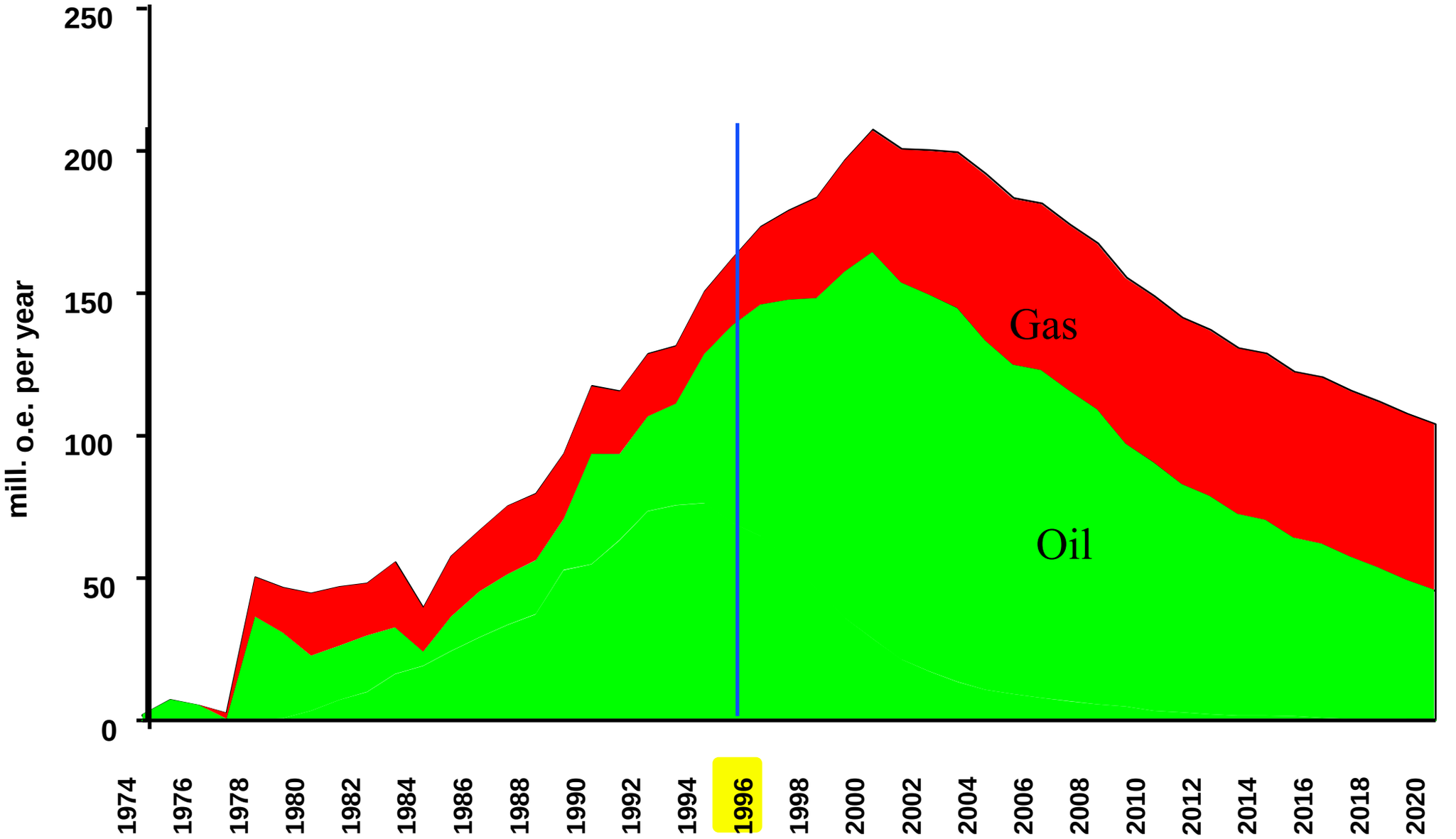


- **Number of accumulations**
- **Sizes with ranges of uncertainty**
- **Confirmed versus unconfirmed plays**

Previous and present estimates of total resources

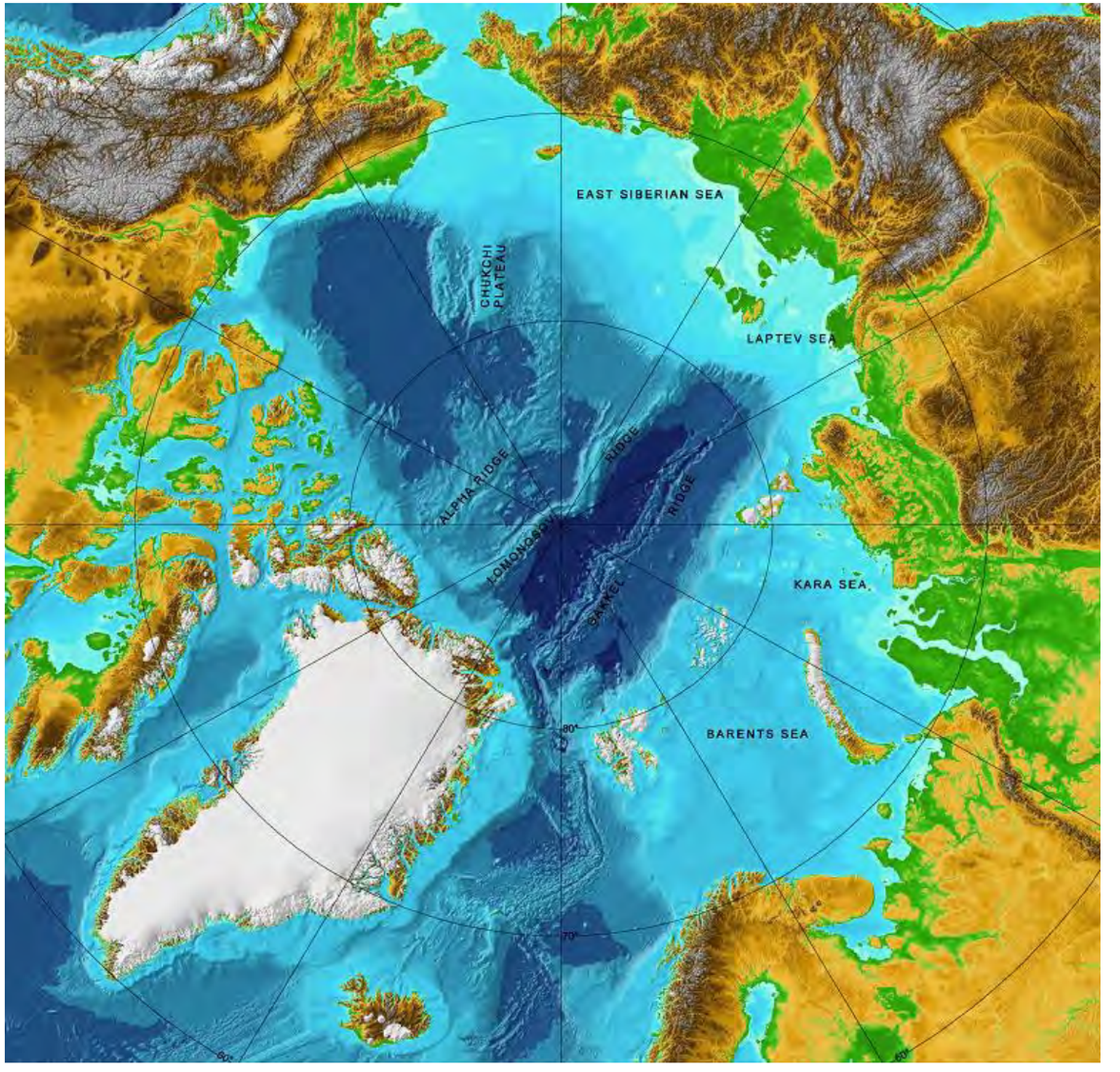


Production forecast



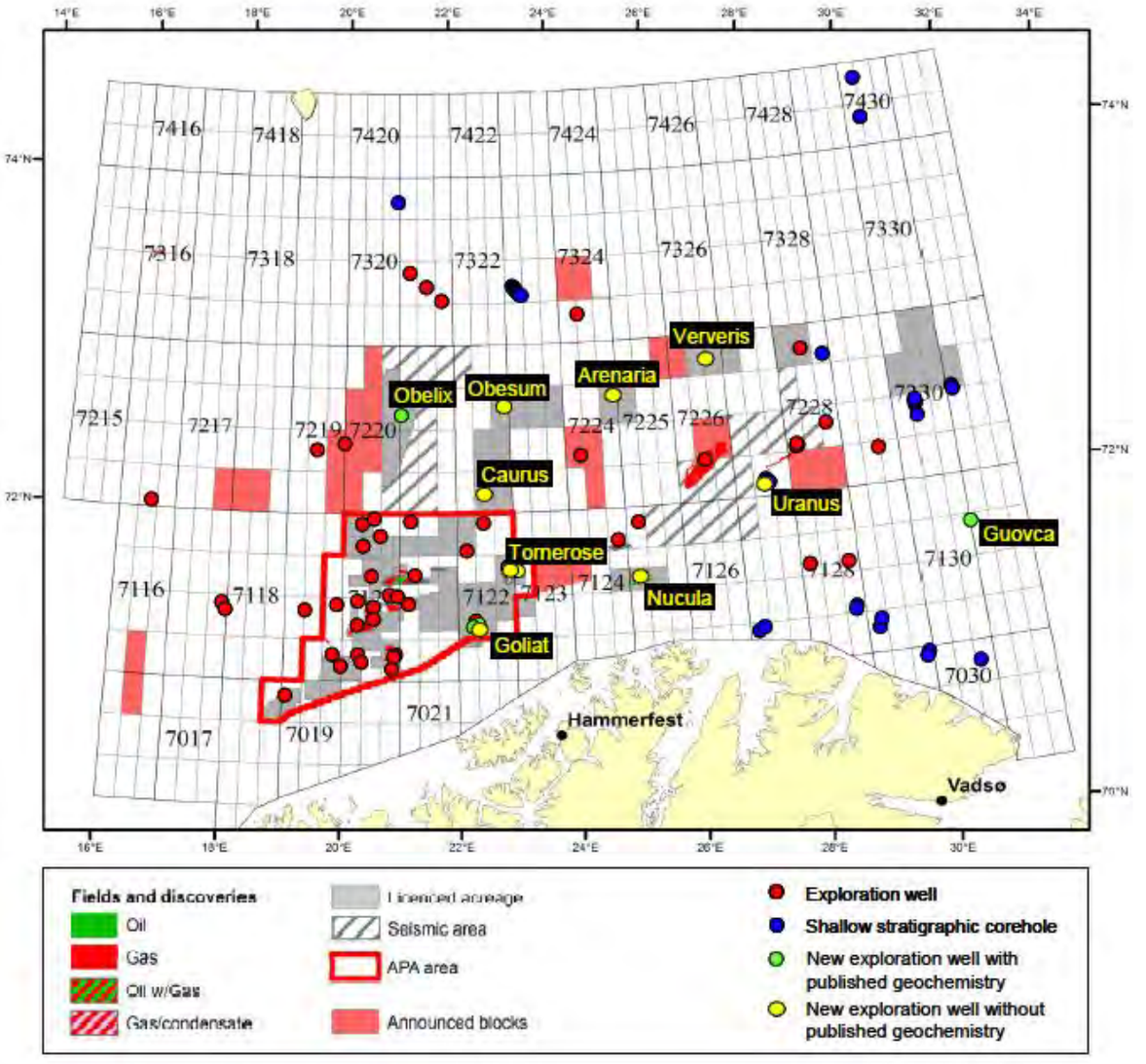
Exploration history of the Barents Sea

- Opened for exploration in 1980
- 66 exploration wells drilled
- First discovery 7120/8-1 Askeladd in 1981 (gas)
- Snøhvit discovered in 1984 (oil and gas)
- Goliat discovered in 2000
- Petroleum system proved in the Nordkapp Basin in 2001 (Pandora)
- Drilling results 2005 / 2006 positive related to pre-jurassic source rocks and reservoirs



Source: USGS, Statoil

Case study: Barents Sea



Case study: Barents Sea

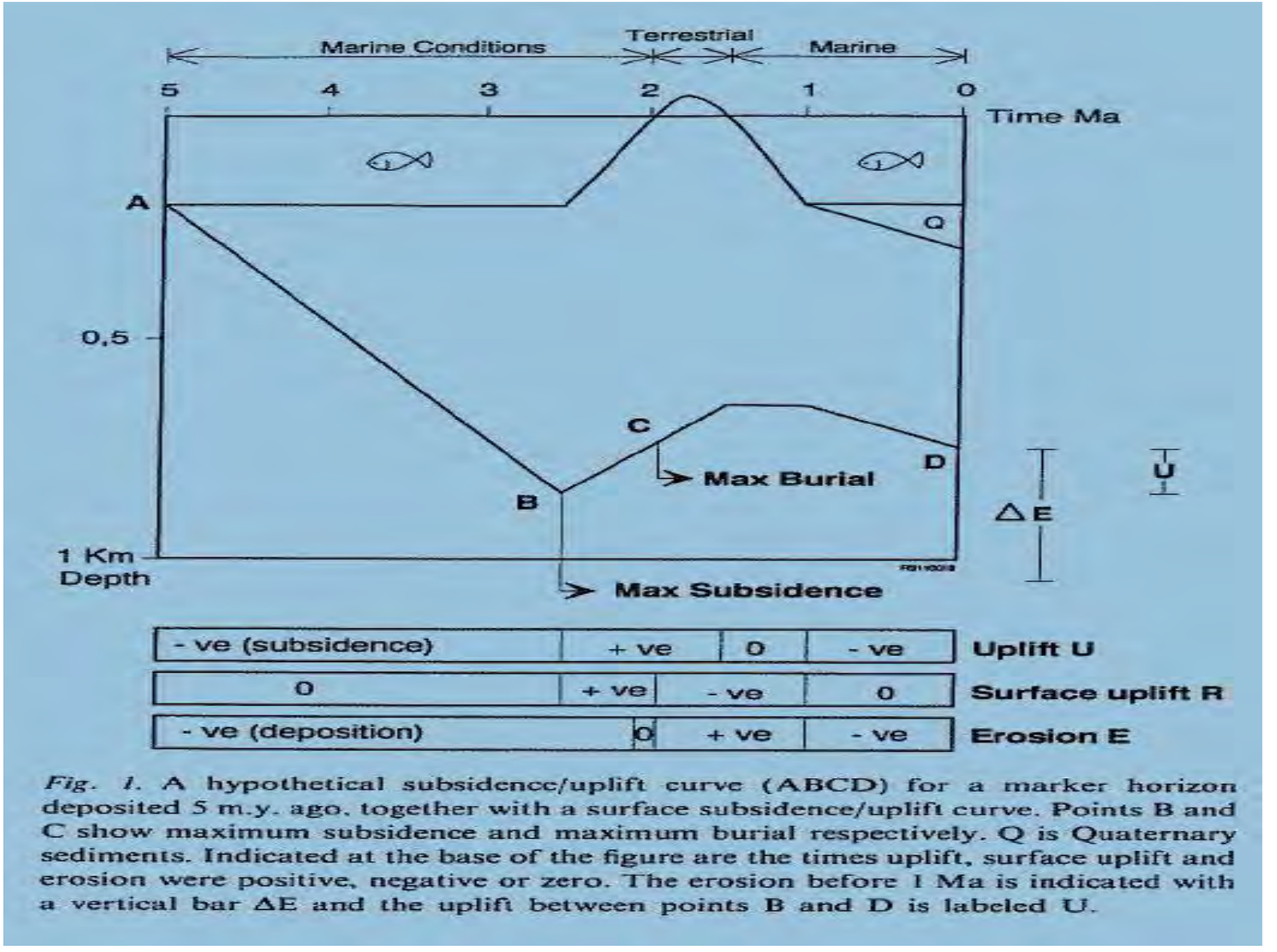


Fig. 1. A hypothetical subsidence/uplift curve (ABCD) for a marker horizon deposited 5 m.y. ago, together with a surface subsidence/uplift curve. Points B and C show maximum subsidence and maximum burial respectively. Q is Quaternary sediments. Indicated at the base of the figure are the times uplift, surface uplift and erosion were positive, negative or zero. The erosion before 1 Ma is indicated with a vertical bar ΔE and the uplift between points B and D is labeled U.

Case study: Barents Sea

Source Rocks:

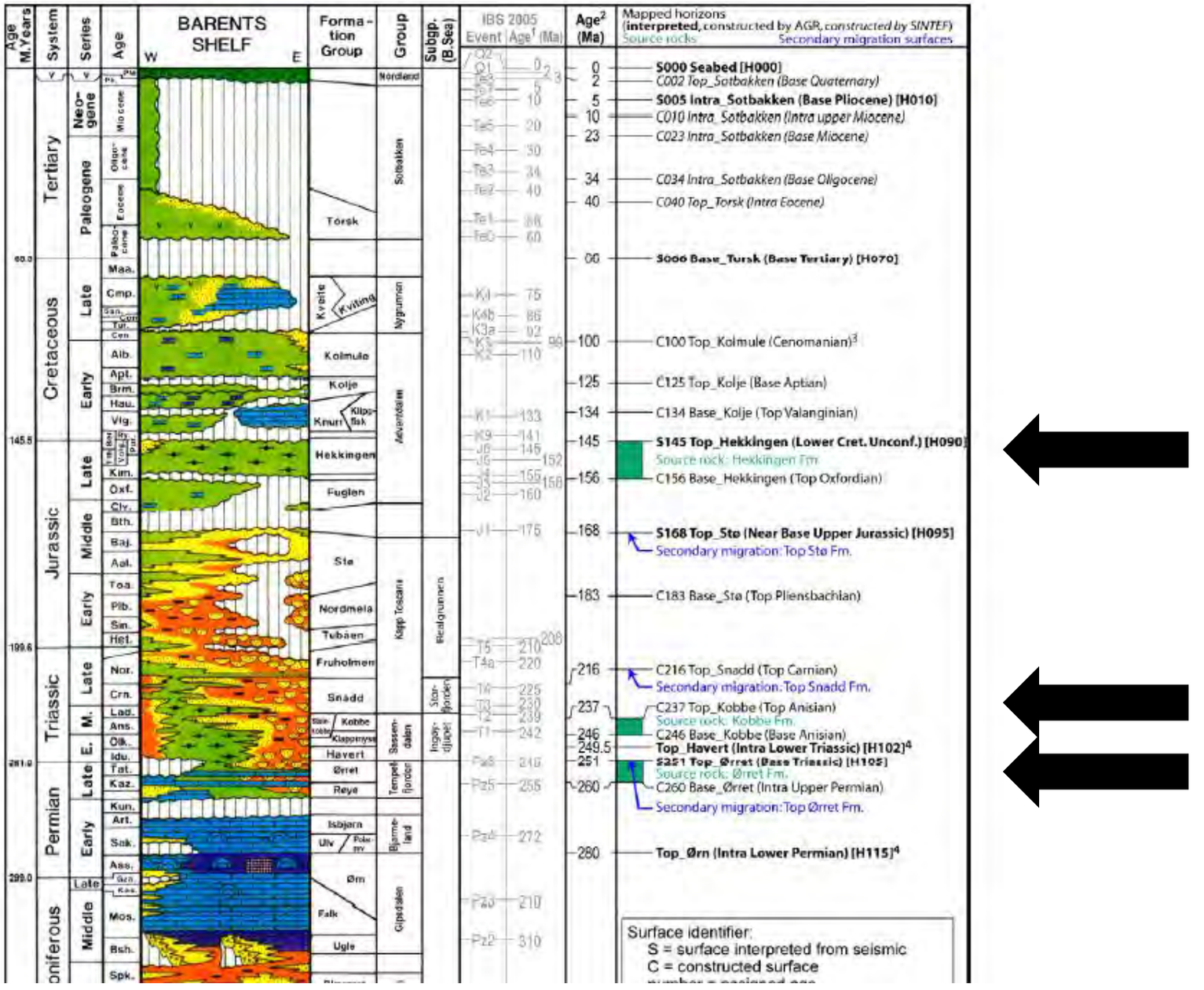
Hekkingen fm.: Distal marine, anoxic marine with some terrestrial. TOC 6-9%, 350-430 mg/g HI-potential.

Kobbe fm.: more variable and local distribution (where?), TOC up to 8%, HI to 480 mg/g.

Ørret fm.: only penetrated on few wells. Overmature.

Maturation, expulsion and secondary migration can be modeled.

Case study: Barents Sea sourcerocks



Case study: Barents Sea

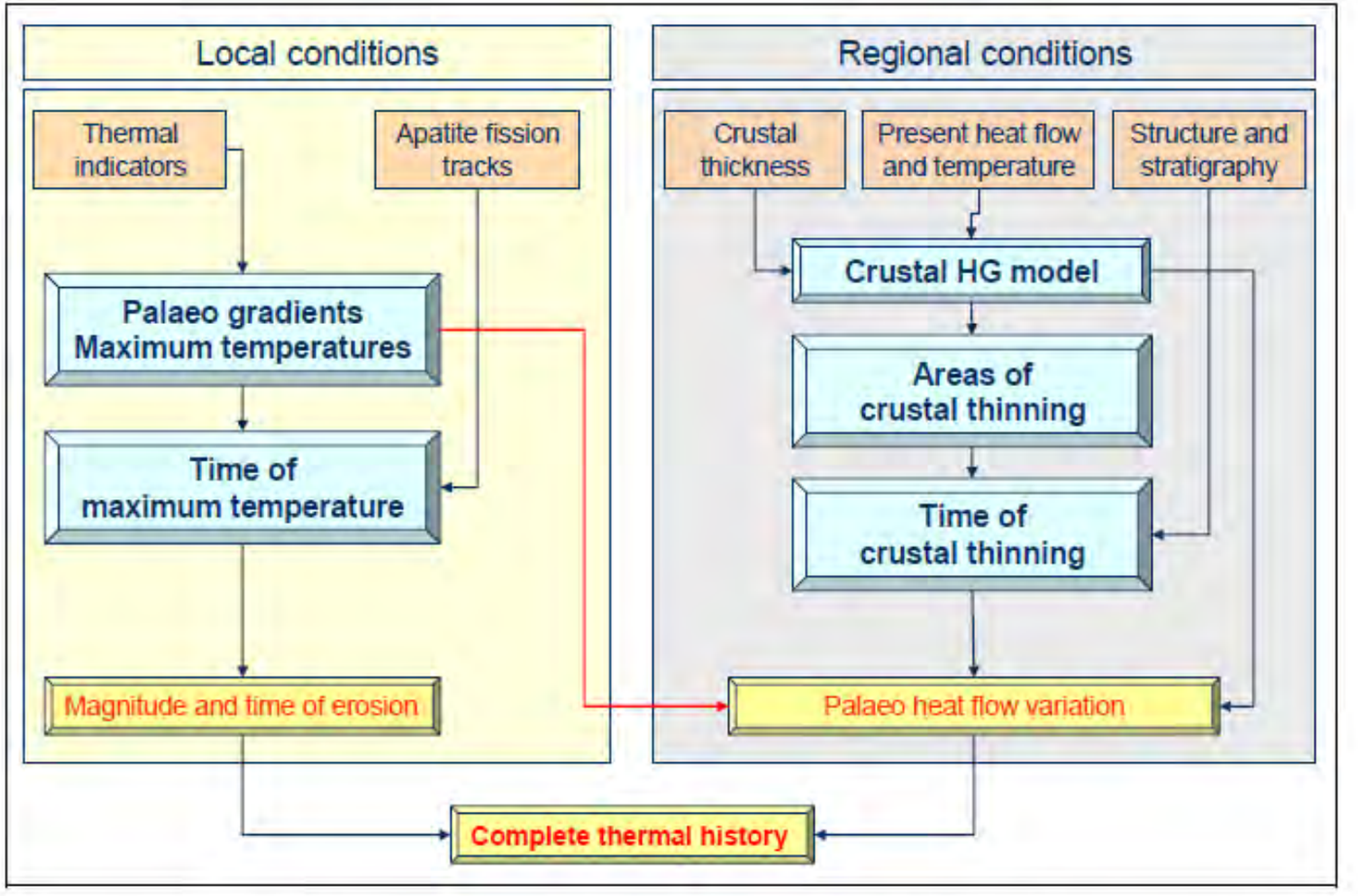


Figure 4.1 *Work flow of thermal history investigation. HG model: Heat generation model.*

Case study: Barents Sea SR thickness

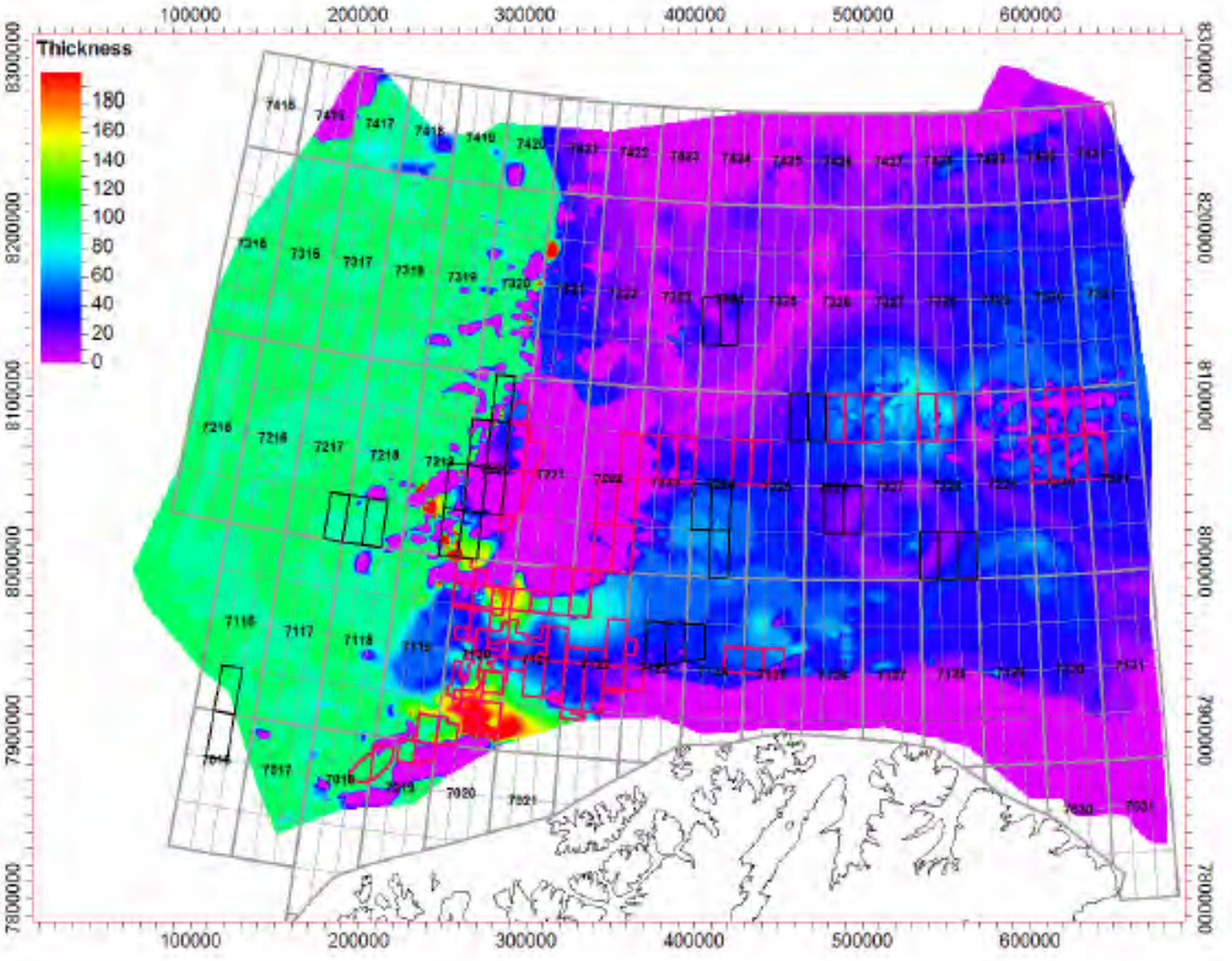


Figure 6.2 *Thickness maps (m) of the Hekkingen Formation in the IBS 2005 (top) and the BMU 2008 (bottom).*

Case study: Barents Sea scenarios

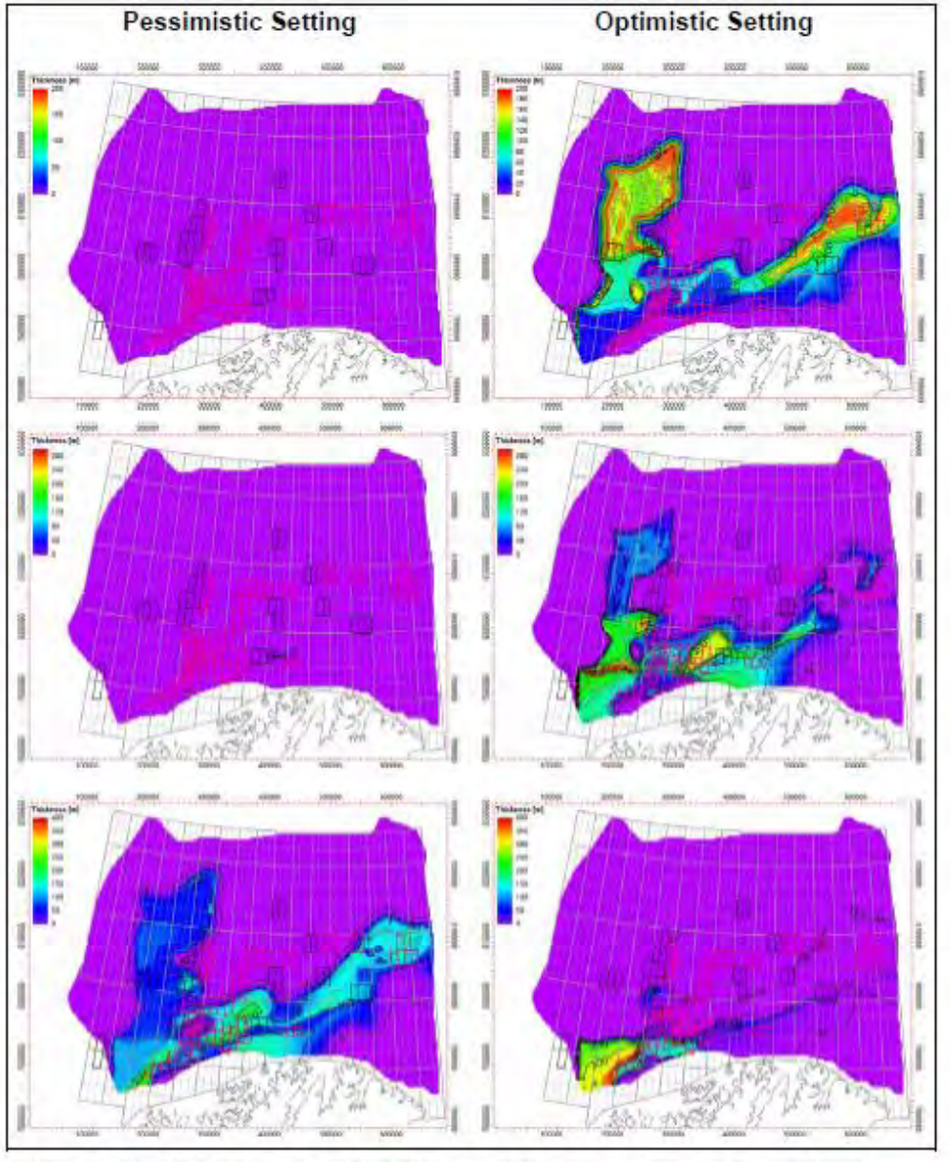
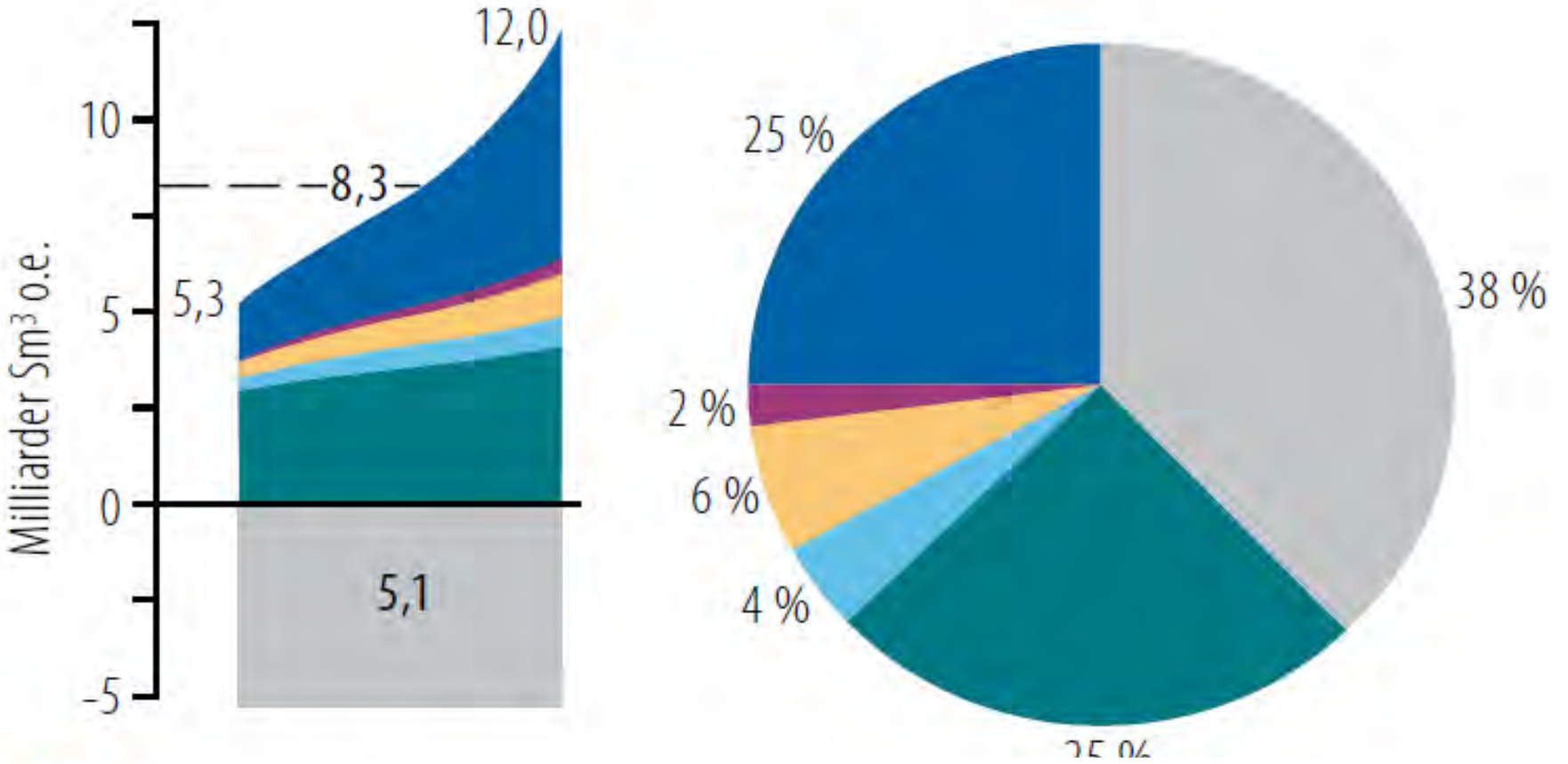


Figure 6.35 Maps of accumulated thickness of Ørret Formation sediments having very good (top), good (centre) and fair (bottom) hydrocarbon generation potential. Left: Pessimistic Setting, right: Optimistic Setting.

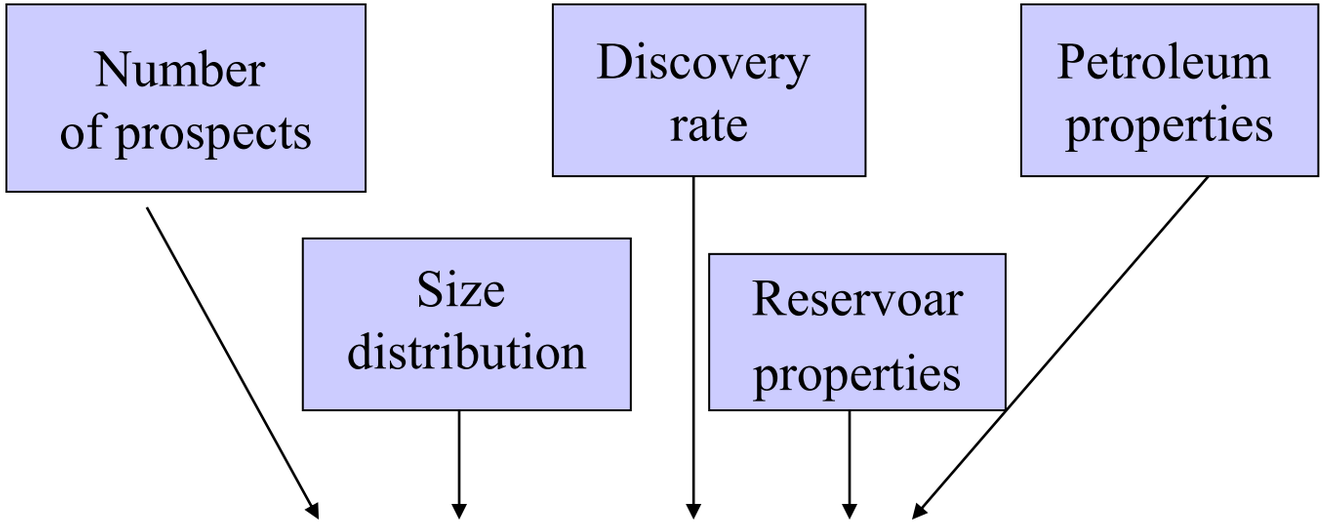


Distribution of total recoverable petroleum resources 31.12.2008

NPD Resource report 2009

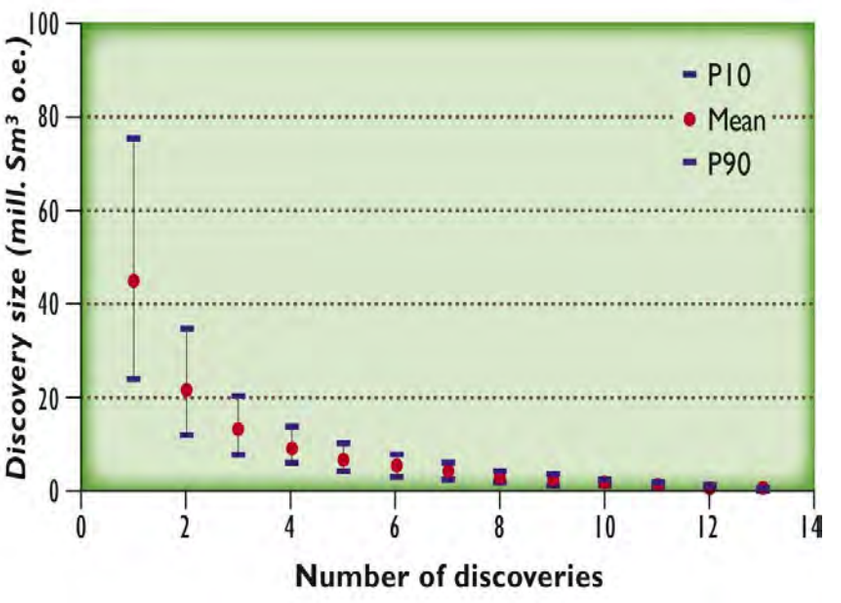
Statistical modeling

Input data:

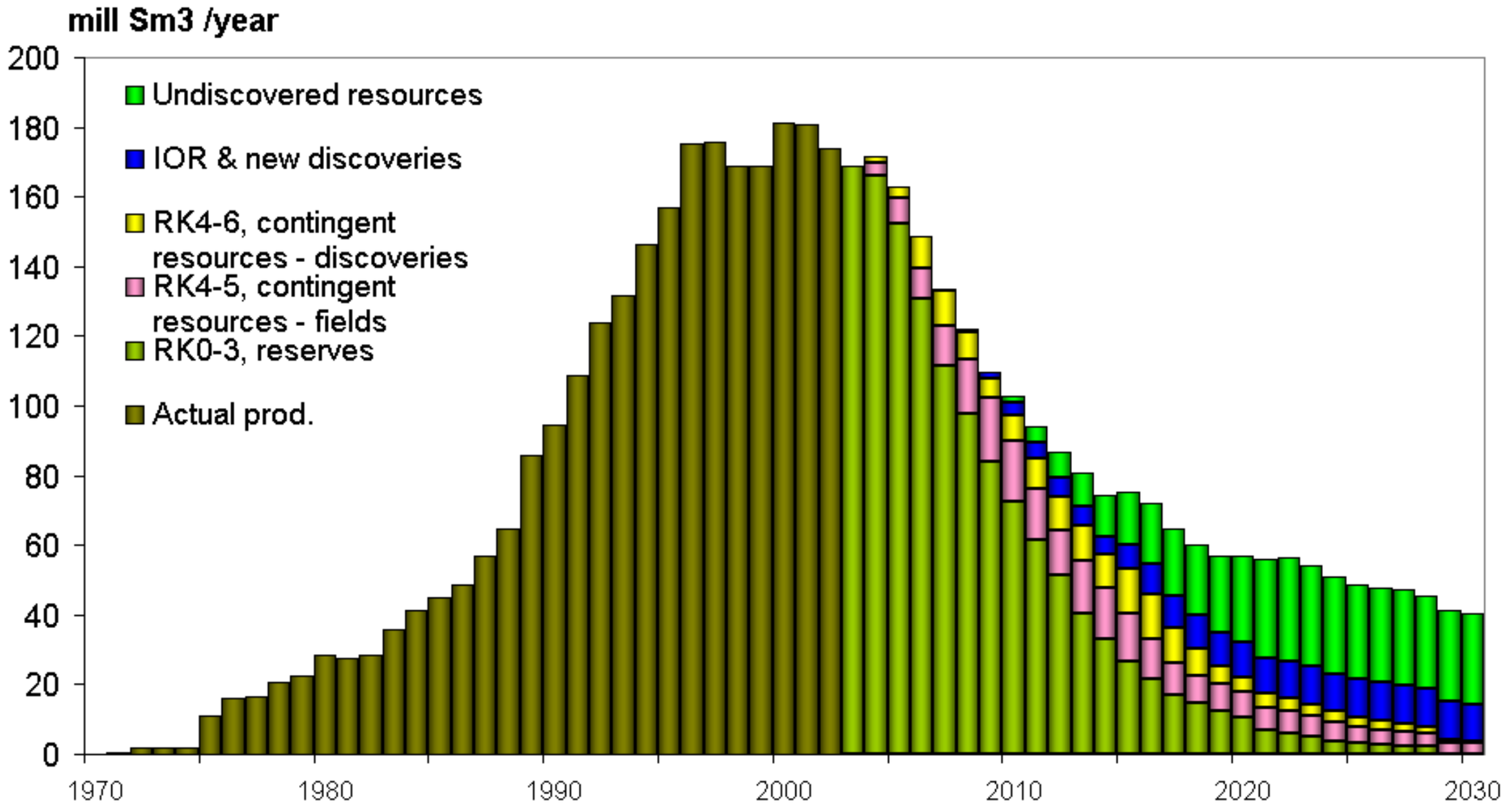


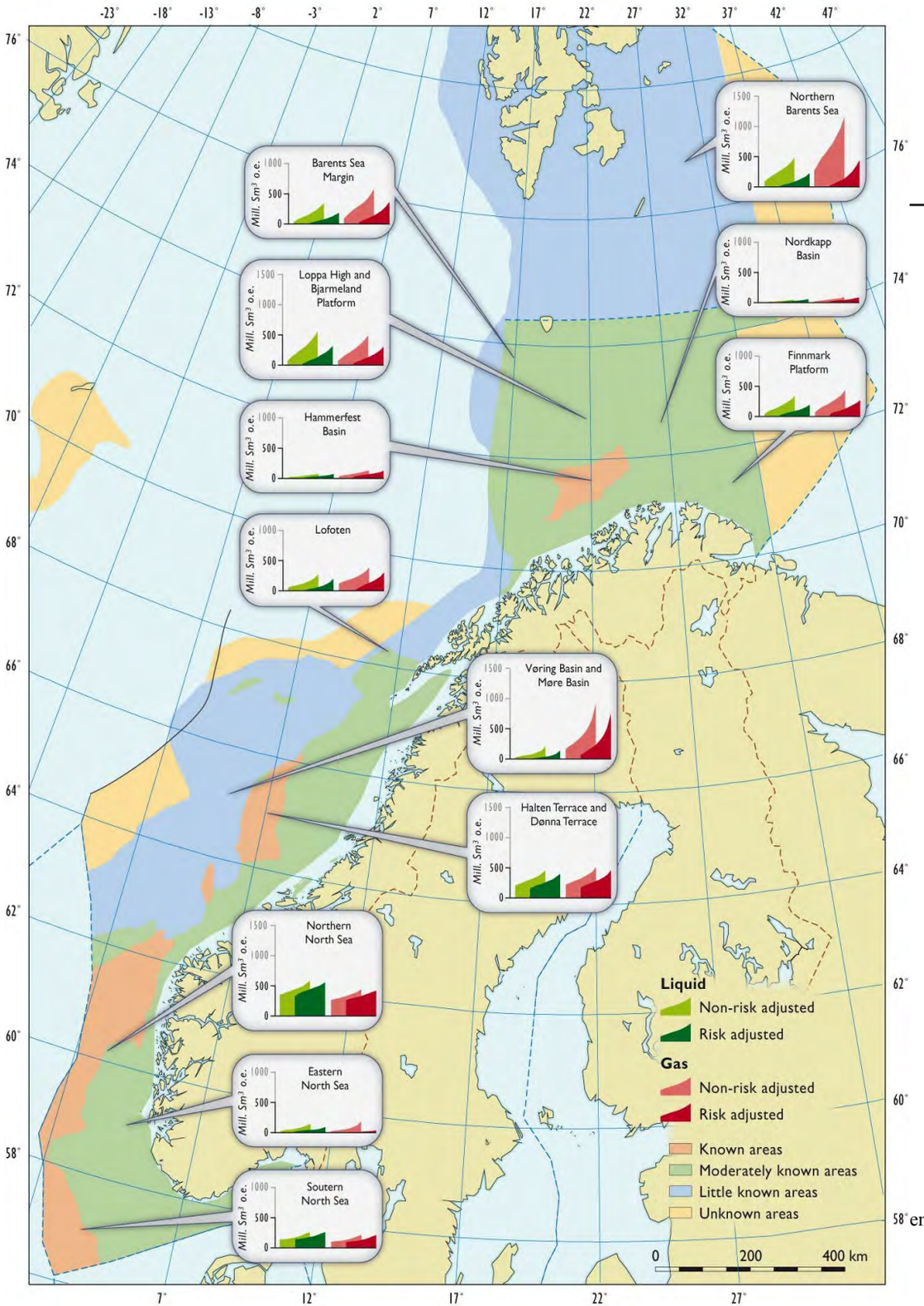
Assessment software:

Results: Number and size distribution of future discoveries, volume of oil, gas and condensate.



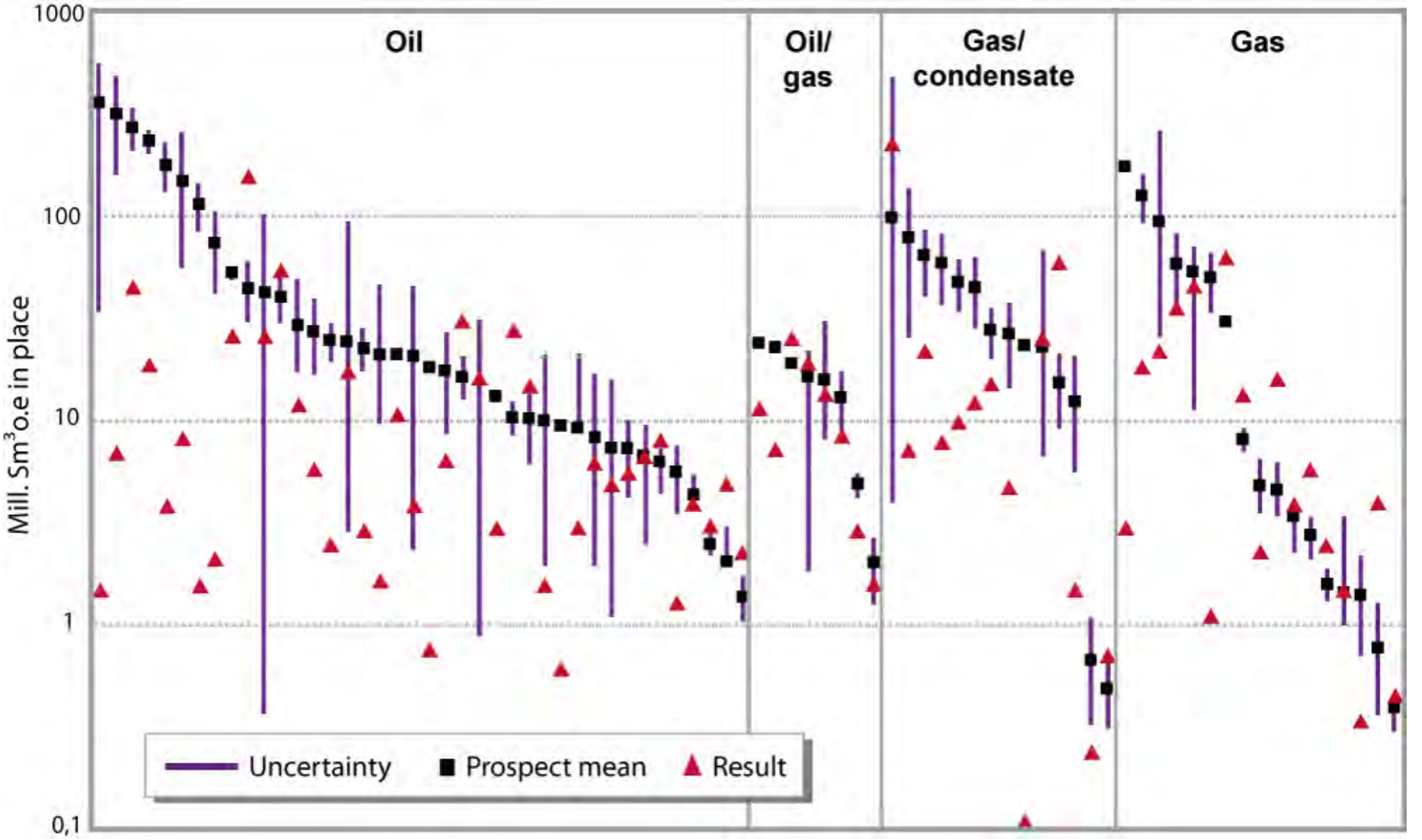
Norwegian Oil Production, historic and forcast





Resource account for Norwegian shelf

Systematic analysis based on all data acquired

Published on paper and internet

Discoveries ranked by prognosed resource estimates, sorted on prognosed HC - phases