Case Study
CO_2 Storage

Smeaheia Fault Block

The Smeaheia Fault Block, offshore Norway in the Northern North Sea, has been envisioned as a potential candidate for CO_2 storage as its Sognefjord, Fensfjord and Krossfjord Upper Jurassic formations are regionally known to have good to moderate reservoir properties, be structurally compartmentalized and being capped by the shaly Heather and Draupne formations acting as primary seal.

Location:
Horda platform, North Sea

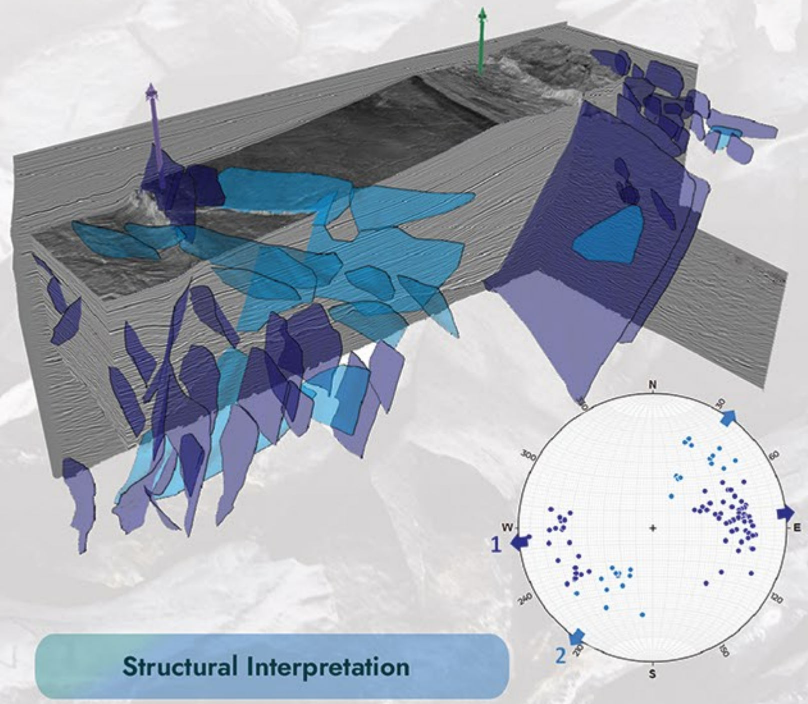
Surface area:
450 km²

Age of sediment:
Triassic to Miocene

Geological context:
Rifting and Passive Margin

Depositional environment:
Coastal to Shallow Marine

Main challenges:
Structural Configuration
Depth conversion
Trap GRV estimation



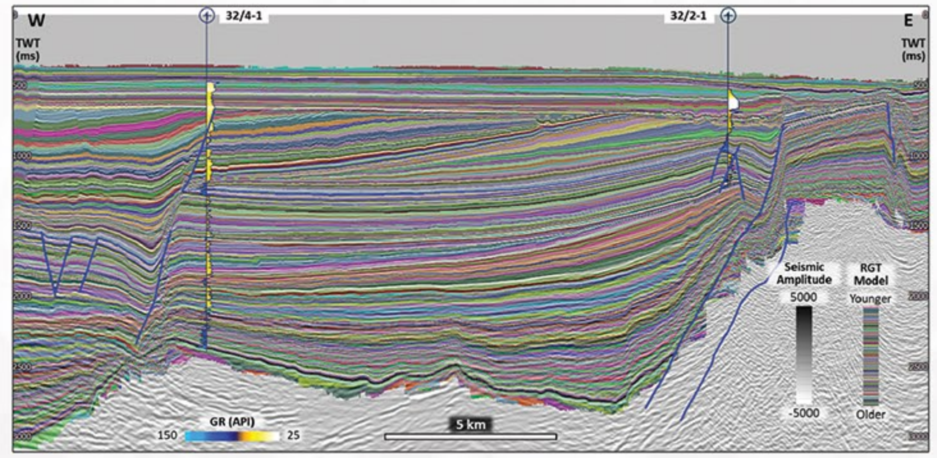
Structural Interpretation

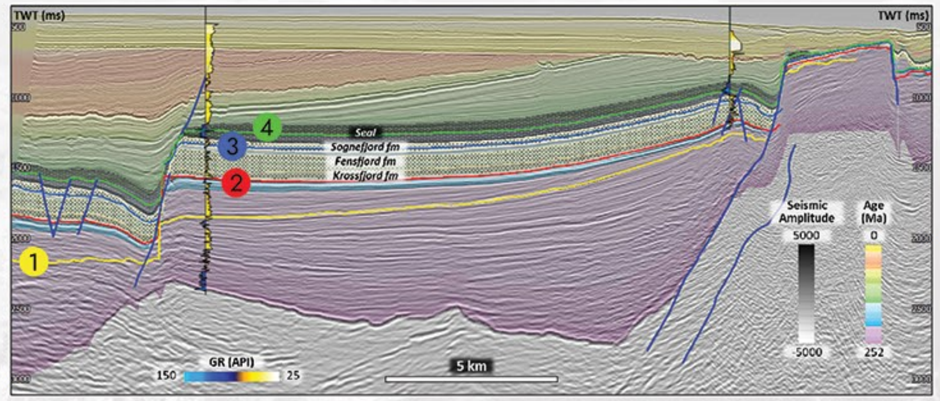
Structural interpretation allows identifying the different phases of deformation impacting the sediment deposits and characterizing the compartmentalization of the zone.
Three phases of age extension can be recognized trending NE-SW to E-W and later NW-SE, with two major fault zones, the Øygarden Fault Zone to the East and the Vette Fault Complex to the West, delimiting a main platform compartment. This main compartment is itself compartmentalised with faults of smaller displacement.

Classic Seismic Interpretation Workflow Applied to CO_2 Storage Appraisal

Stratigraphic Interpretation and RGT Model

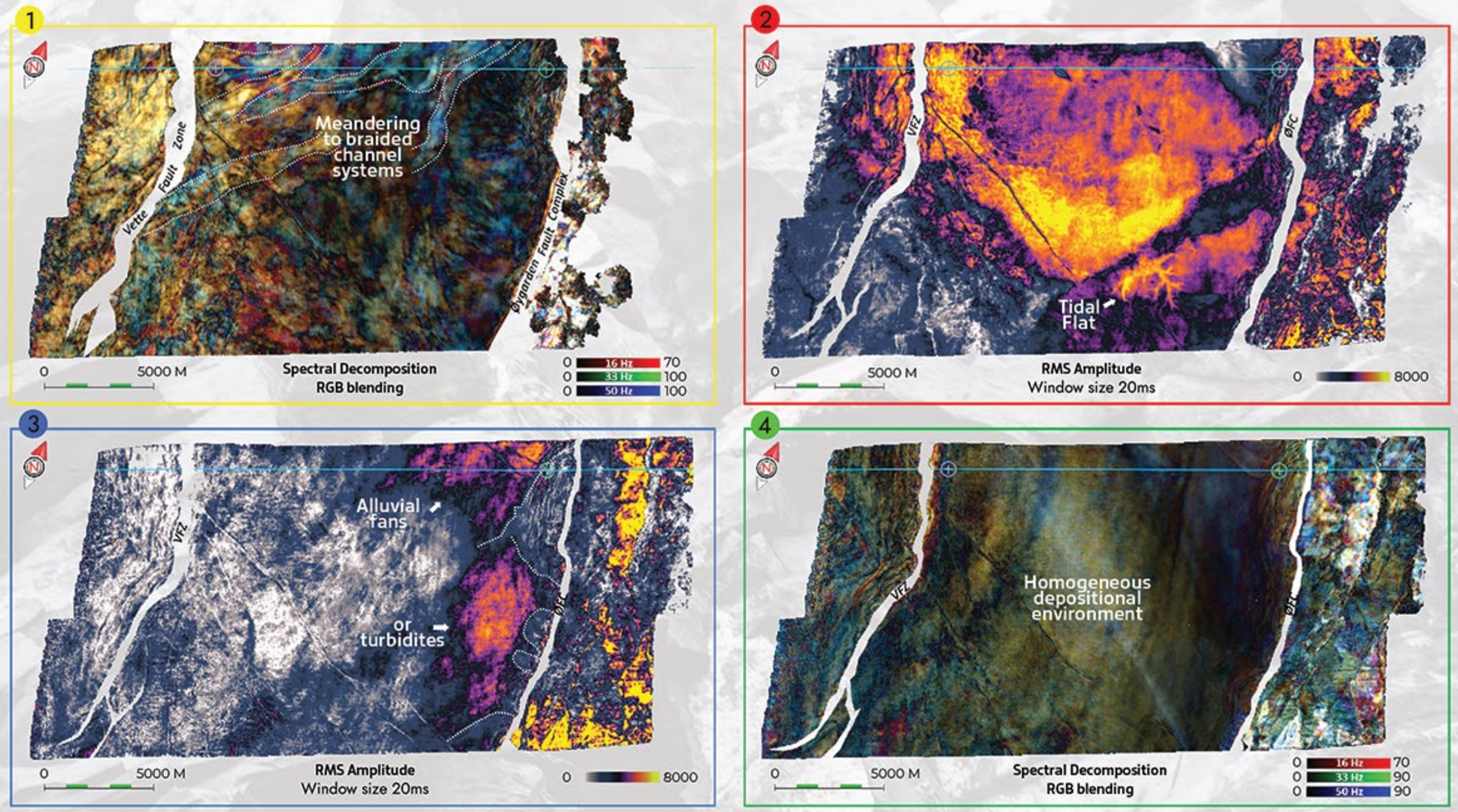
Stratigraphic interpretation supported by the understanding of the structural organization permits capturing the lateral and vertical extension of the sediments inside the whole seismic volume through the creation of a Relative Geological Time (RGT) model.
The combination of seismic and well log data with regional geological context is key to the creation of a consistent RGT model that will be leveraged to locate reservoirs of interest meeting the required conditions for an optimal and long-lasting CO_2 sequestration.





Stratal Slicing and Attribute Analysis

The creation of dense series of stratal slices (Horizon Stacks) whose geometry derives from the RGT model allows scanning the geological content of the seismic volume, consistently with the geological depositional ages. This technique helps assessing depositional environments and revealing geological features.



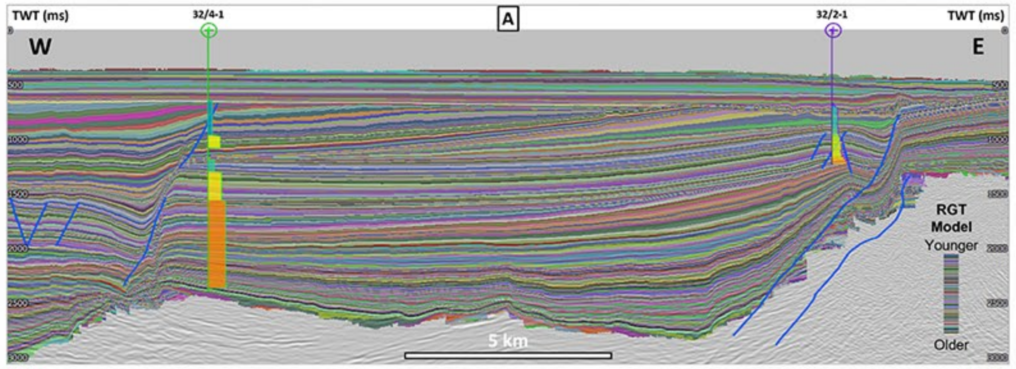
Attribute analysis confirms the continental and fluvial nature of the underlying Triassic formations. The Sognefjord, Fensfjord and Krossfjord Upper Jurassic formations show little variation in the nature of the deposits but include several westward flowing fairways and fans from the eastern Øygarden Fault Complex. The shaly Draupne formation displays a very homogeneous pattern of deposition throughout the survey.

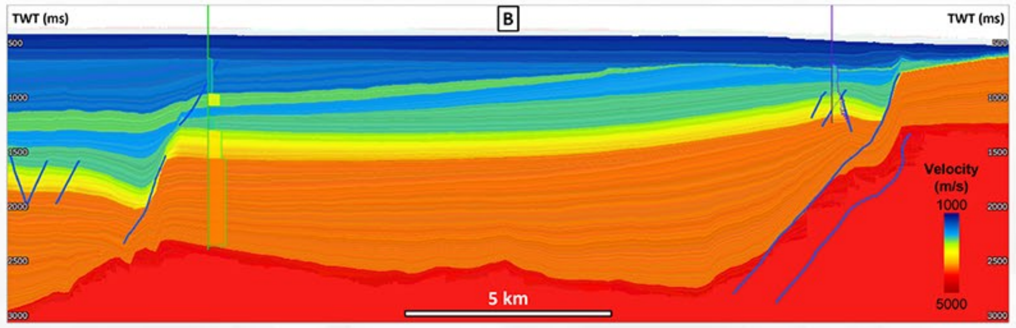
Classic Seismic Interpretation Workflow Applied to CO_2 Storage Appraisal

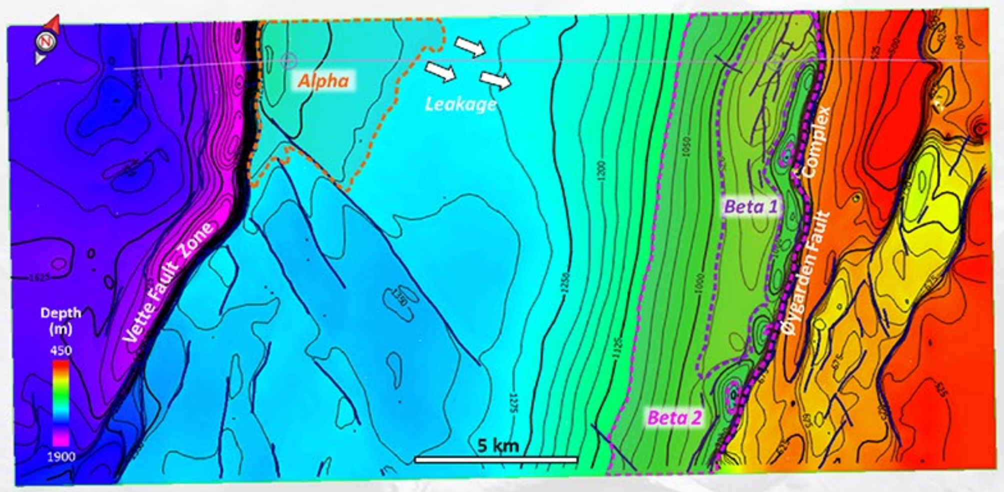
Velocity Modelling and Depth Conversion

Reservoir appraisal requires a conversion in depth domain to identify closure points and spill points, and to undertake volumetric estimations. Velocity models can be built according to several methods.
In this example, simplified constant or linear velocity values are approximated from the interval velocity logs and populated inside corresponding stratigraphic layers whose geometries are defined by the RGT model.

The depth conversion is applied on the seismic volume, the faults and interpreted horizons being identified as the top and bottom of the projected reservoir formations.

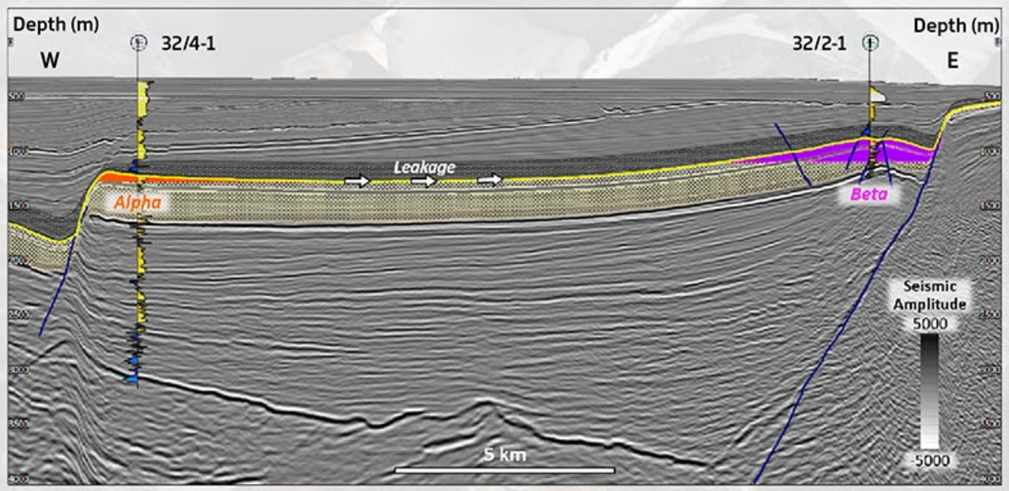






Once analysing the data in depth domain, assuming that the spill points outside of the cube are at least as deep as the ones identified inside the available survey area, two potential traps are identified:

- Alpha: a slight structural high along the footwall of the Vette Fault Zone.
- Beta: a small, fractured N-S trending anticline on the hanging wall of the Øygarden Fault Complex (the anticline is more pronounced to the north and flattens to the south of the cube).



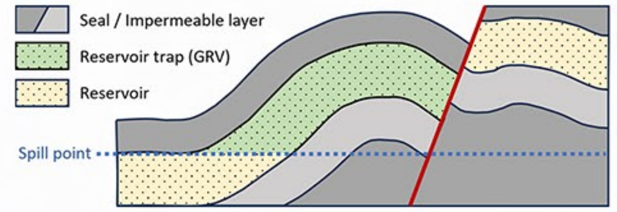
Alpha trap: a CO_2 column comprised between 1195 m (shallowest local closure point) and 1280 m (spill point toward Beta).

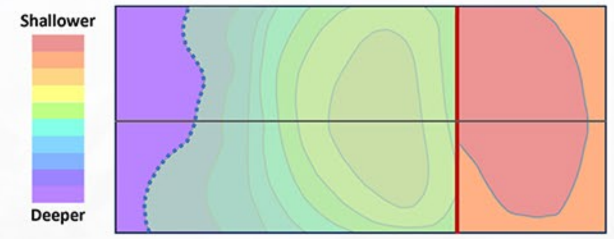
Beta trap:

- Scenario 1 (pessimistic case): a CO_2 column comprised between 800 m (shallowest local closure point) and 980 m (deepest point where the southern spill point is still assessable inside GN1101).
- Scenario 2 (optimistic case): a CO_2 column comprised between 800 m and 1100 m (approximate depth-converted value relating to the CO_2 -formation water contact at 1175 ms proposed in the literature).

Gross Rock Volume Estimation

Once the traps identified, the Gross Rock Volume (GRV) estimation can by undertaken by computing the volumetrics between the top and bottom of each reservoir formation, within the limit of the spill point. In this case study, we consider that the three Sognefjord, Fensfjord and Krossfjord formations are permeably connected.

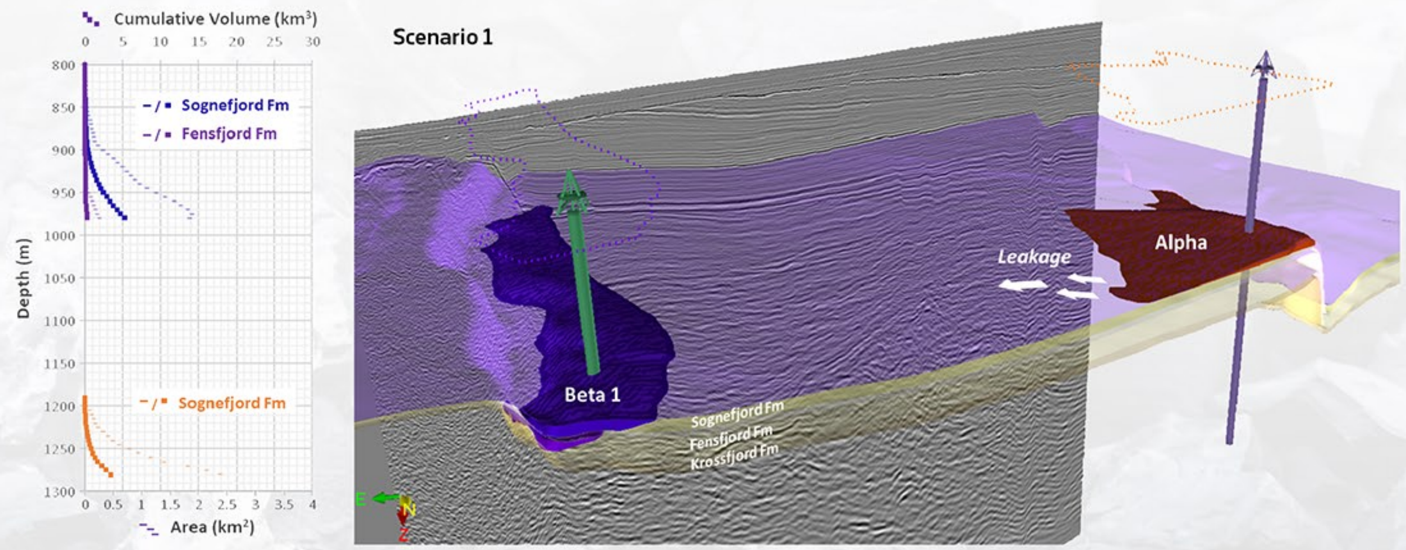


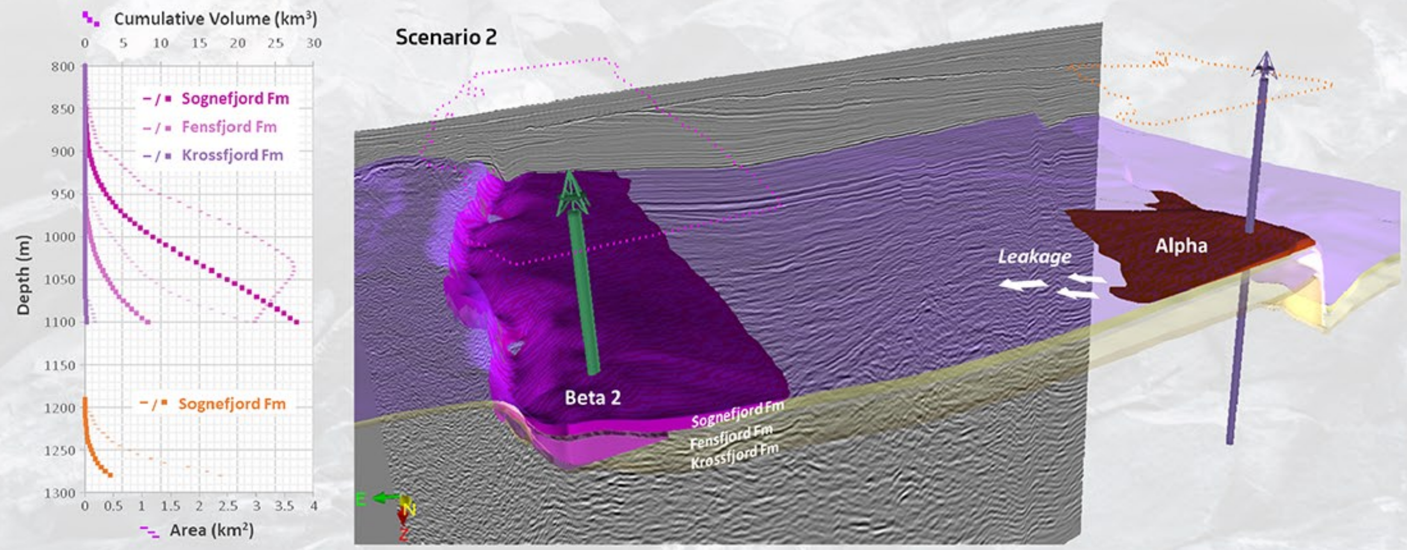


Cumulating Alpha and Beta traps, the following GRV can be worked out inside the GN1101 cube:

- Scenario 1 (more pessimistic) cumulates a total GRV of 1.20 km^3
- Scenario 2 (more optimistic) cumulates a total GRV of 5.31 km^3

Considering a reservoir porosity of 30%, fully occupied by supercritical CO_2 (beyond 800 m in depth) of density of ca. 850 kg/m^3, we can estimate a storage capacity between ca. 0.3 and 1.4 GT inside the Sognefjord, Fensfjord and Krossfjord formations intersected by the GN1101 cube.





Although simplifications are made and parameters such as precise reservoir porosities and CO_2 solubility in the brine should be considered to get accurate storage capacity, we obtain a first level of CO_2 storage appraisal, both qualitatively in terms of structural extent and quantitatively in terms of volumetrics.

The use of the Smeaheia dataset is the courtesy of Gassnova and Equinor (https://co2datashare.org/smeaheia-dataset/static/SMEAHEIA%20DATASET%20LICENSE_Gassnova%20and%20Equinor.pdf),. The use of the Wells data is the courtesy of the Norwegian Petroleum Directorate.