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Relationship between salt and crustal tectonics in the Sørvestsnaget Basin, SW Barents Sea

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Due to the particularity of this online version of EGU, the following presentation doesn't show the dataset used and the interpretation of the salt bodies (confidentiality reasons)

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https://www.saltgiant-etn.com/

Main physical characteristics of the salt

- **Low viscosity values**
  - Low temperature and geological times: **salt moves as a** Newtonian fluid (= viscous behaviour)
  - Decollement layer

- **Relative incompressibility/constant density (low)**
  - Partial contribution of density inversion to salt movement

- **Sealing characteristics**
  - Possible gas trap/overpressure development, storage sites

- **High velocity of the seismic waves in the salt** (4500 m/s)
  - Strong acoustic impedance contrast between salt
  - and sediments

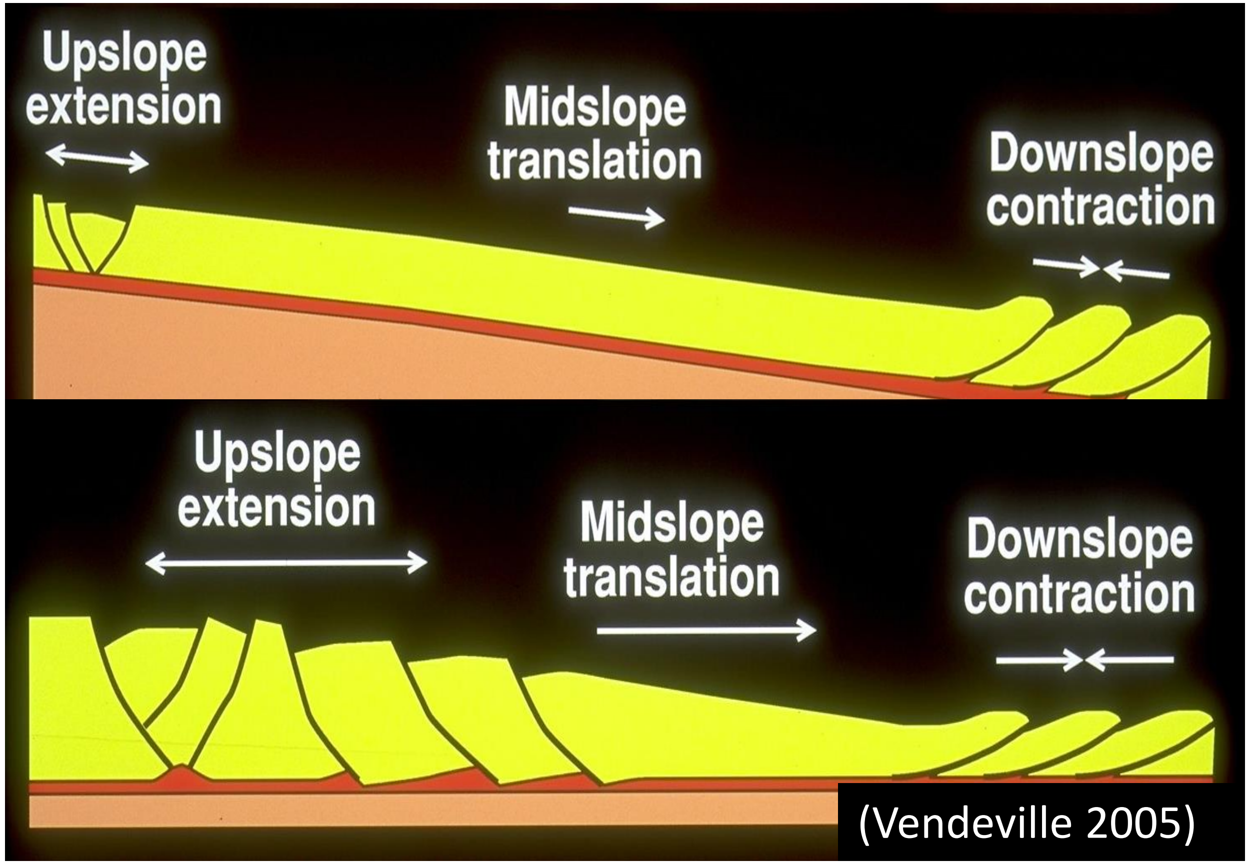
Nuclear waste in an abandoned German salt mine

Hudec & Jackson 2007; LeCompte, 1965; image source: National Geographic

Salt tectonics mechanisms and domains

a

b



Schematization of gravity gliding (a) and gravity spreading (b)

Gravity gliding:
Bottom surface has a component of **dip** in the movement direction
It does **no**t require **internal deformation** of the translating body, and the flow is parallel to the dip surface.

Gravity spreading:
Upper surface must have components of **dip** in the movement direction.
Driving energy causes motion of the material toward the basal surface, creating **deformation** of the spreading body.

Gaullier, 1993; Gaullier and Vendeville, 2005; Jackson & Hudec, 2016; Rowan et al., 2012; Vendeville, 1987; Vendeville, 2005 (image); Warren J.K., 2006;

Reactive-active-passive diapirism

- **reactively**:

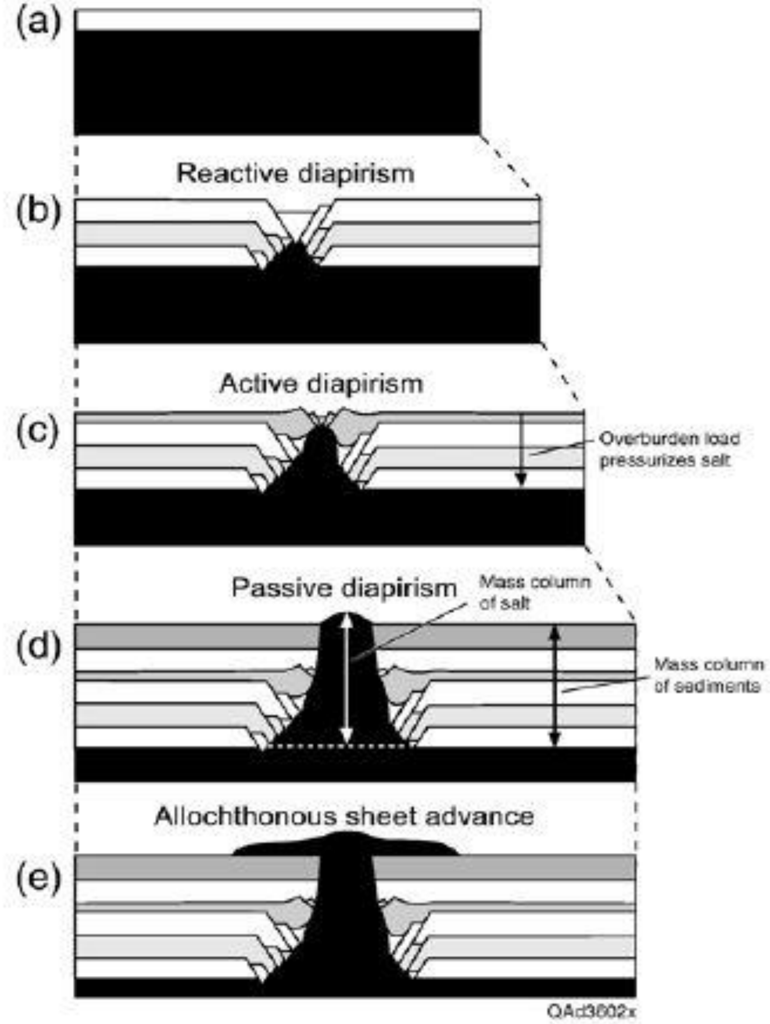
  Extensional context, space in the overburden filled by the salt

- **actively**:

  The active lift and shove aside the overburden essentially controlled by the roof thickness

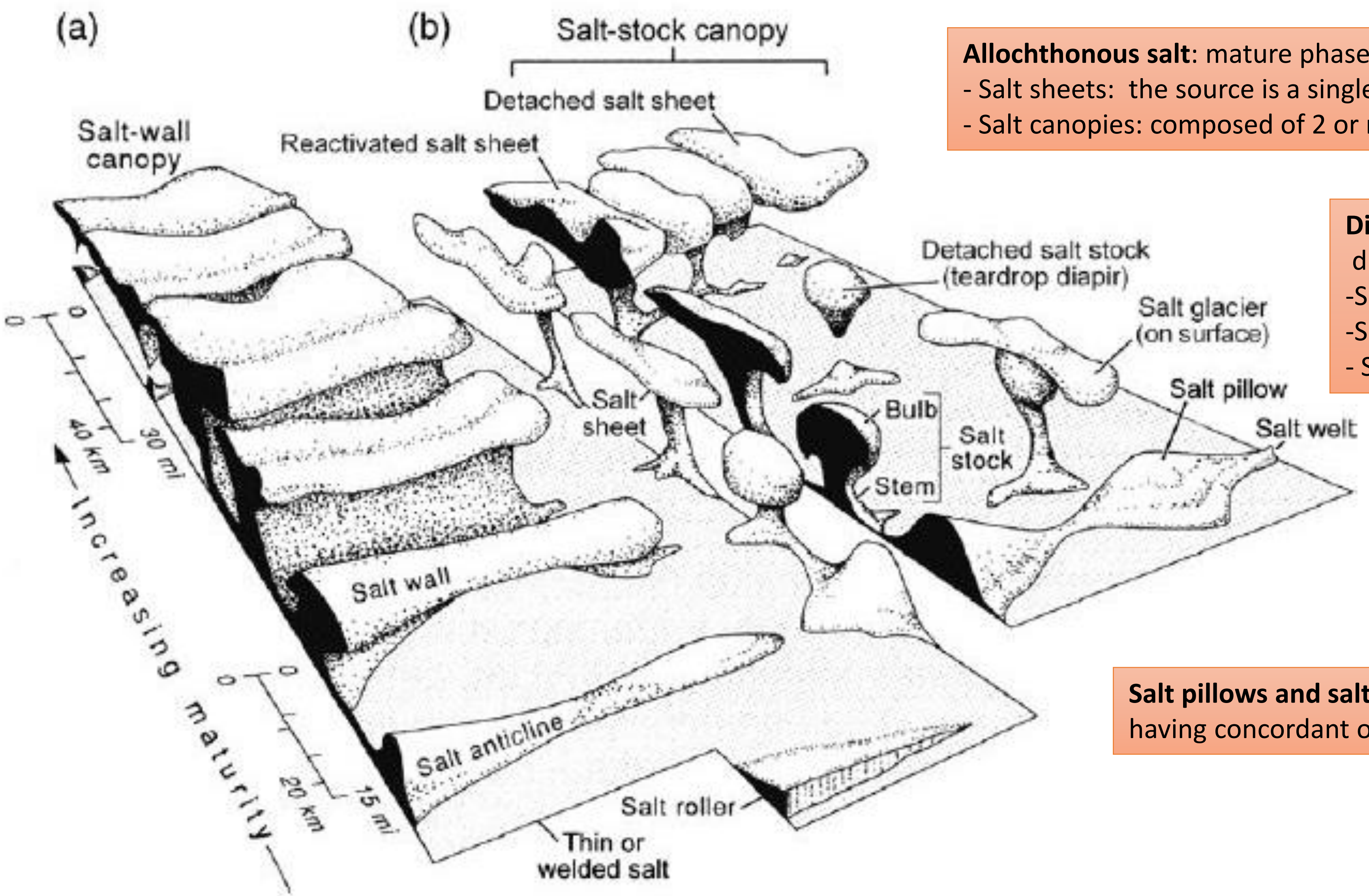
- **passively**:

  The surrounding sediments accumulate, and the top of the diapir maintain its position near or at the surface



Gaullier & Vendeville 2005, Hudec 2007; Vendeville & Jackson 1992a (image), Warren J.K., 2006;

Salt tectonics structures



Allochthonous salt: mature phase of salt tectonics
- Salt sheets: the source is a single feeder
- Salt canopies: composed of 2 or more salt sheets

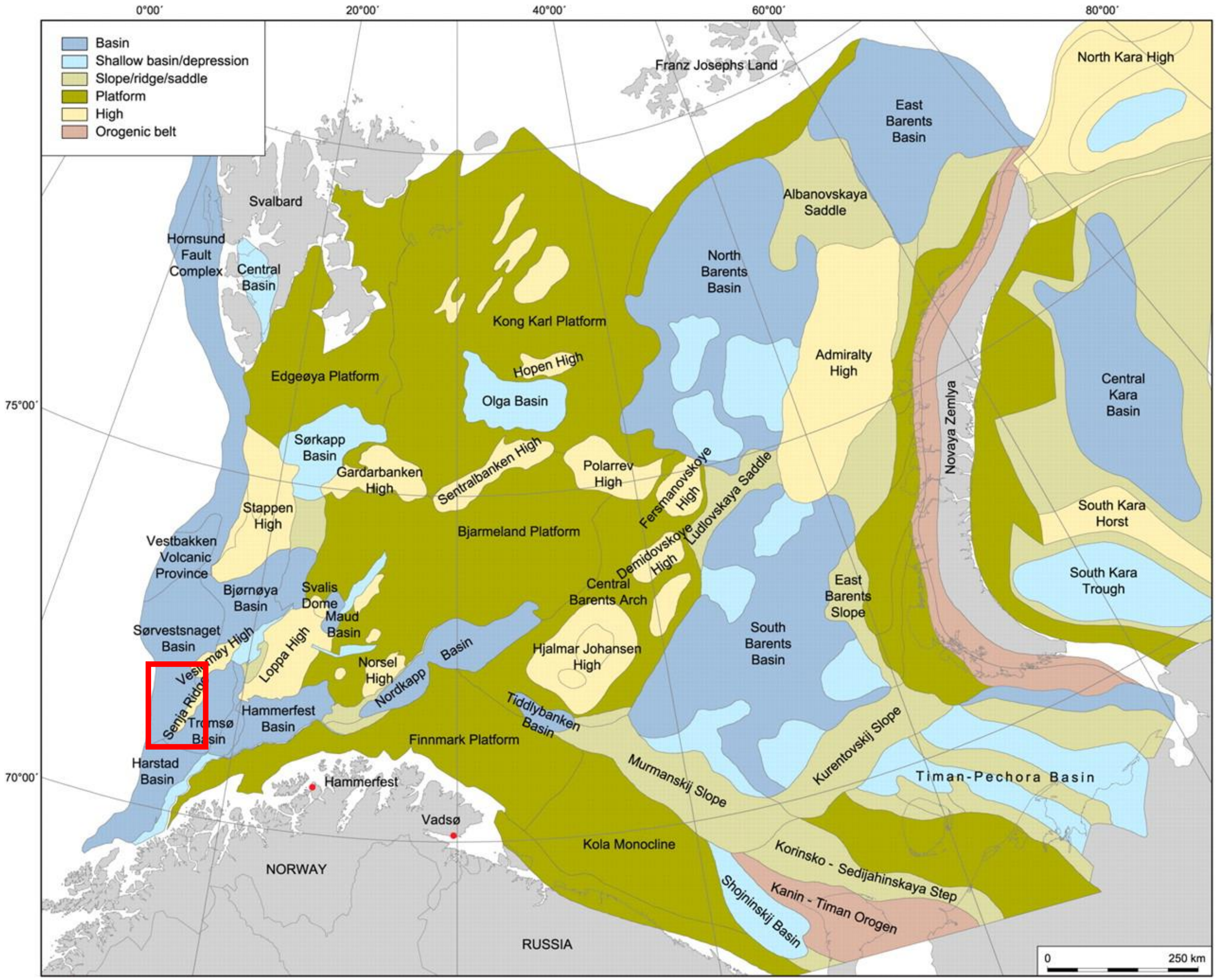
Diapirs: Salt structures having discordant overburden:
-Salt diapirs
-Salt stocks
- Salt walls

Salt pillows and salt anticlines: salt structures having concordant overburden

Schematization of the different salt tectonics structures, from Jackson & Talbot 1991

Geological settings of the Sørvestnaget Basin

- Interaction between episodes of orogenic compression and crustal rifting, climatic influence and the effects of Carboniferous-Permian salt deposition
- Deposition of evaporites during Permo-Carboniferous
- Middle Late Jurassic to Early Cretaceous opening of the N-Atlantic and extensional tectonics in the SW Barents Sea
- Formation of the Sørvestsnaget deep Cretaceous and Cenozoic basin
- Northern Hemisphere Glaciation, 2.6 My: erosion of the shelf and sediments deposition



Henriksen et al., 2011. Structural elements f the Greater Barents Sea. In red, the position of the study area.

Aim of the study

- Interpretation of the main salt structures in the Senja Ridge area
- Analysis of the salt tectonics mechanisms:
    - timing of the phases of movement
    - correlation with sedimentary load and crustal tectonics

Data and methods

Name	Data	Area	Year
Carlsen 3D	3D seismic	5,500 km^2	2017
CFI_NBR	2D seismic	200,000 km^2	2009-2012
Merged datasets	Bouguer gravity anomalies	200,000 km^2	2010-2018
Merged datasets	Magnetic anomalies	200,000 km^2	2010-2018
7216/11-1S, 7117/9-1, 9-2, 7218/11-1	Well data	2,440 km^2	1982-2013

-**Horizon interpretation with Kingdom software**

3D seismic interpretation
Manual and filling picking every 8th inline and every 32th to 8th crosslines.
The interpretation has been gridded and snapped to an horizon with a vertical window of 50 ms above and below the grid.

Partial 2D seismic interpretation

-**Integration with gravity and magnetic data** as a constrain for structural interpretation

-**Wells ties**

Main characteristics of the dataset used for this work

Methods

Top of the salt bodies

Level of confidence: High

Interpretation: 8th inline, 32th to 8th crosslines

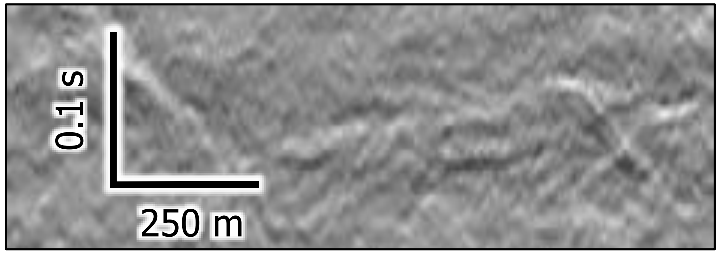
High amplitude continuous reflection, positive polarity

Base of the salt bodies

Level of confidence: medium to low

Interpretation: 8th inline, 32th to 8th crossline

Low amplitude, partly discontinuous reflection, negative polarity

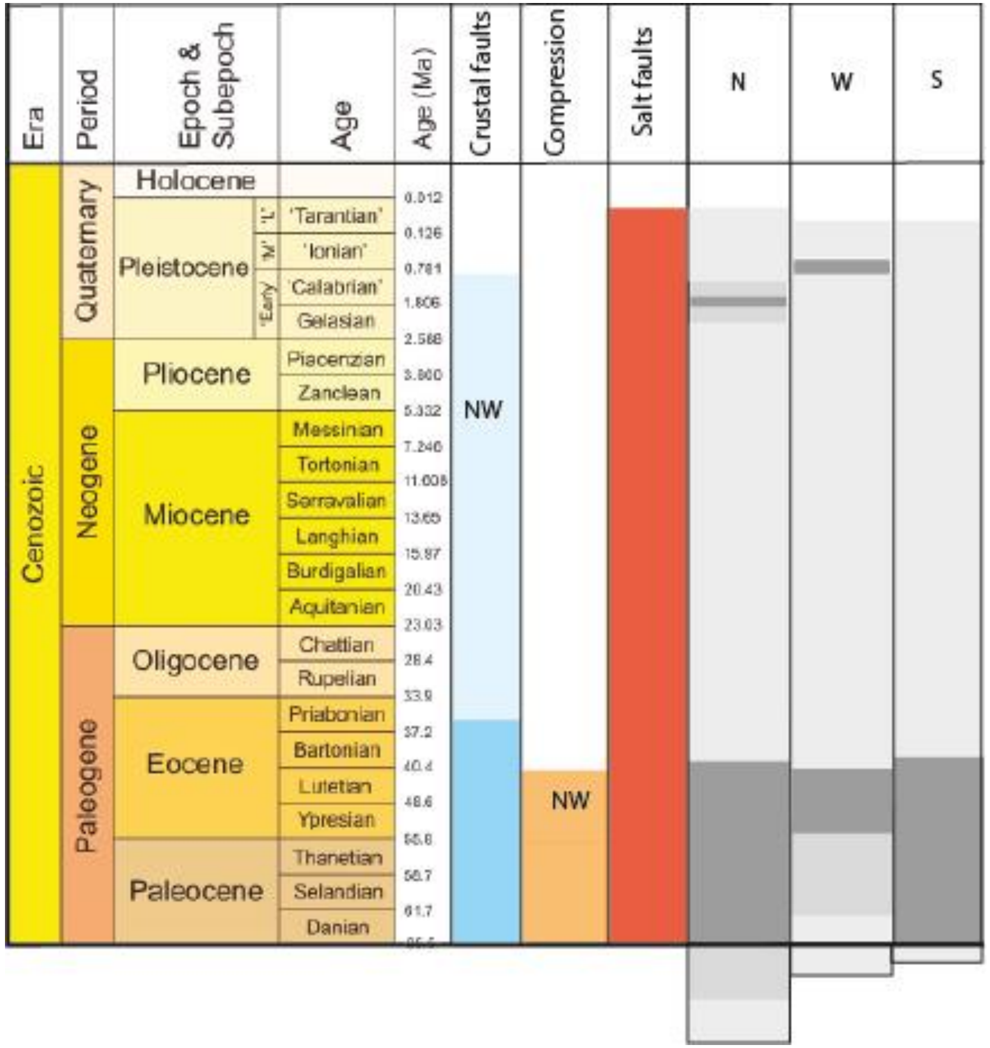


The seismic data interpretation focused on 3 bodies presenting transparent seismic facies and low values of Bouguer gravity anomalies ad magnetic anomalies. The lithology is supposed to be evaporitic.

Results

- Detailed interpretation of the salt bodies in the southern Sørvestsnaget Basin
- Interpretation of crustal faults and salt related faults
- Analysis of the pre-, syn-, post- salt tectonics sedimentary sequences
- Correlation between crustal tectonics and salt movement

Correlation between crustal and salt tectonics



Cenozoic Time scale with the main phases of activity of the crustal faults (light blue), compressional features (orange) and salt related faults (red).
On the right, the main phases of activity divided for the 3 salt bodies (N, W, S): lighter colors represent the phases of minor movements, while darker grey marks the phases of maximum activity of the salt structures.

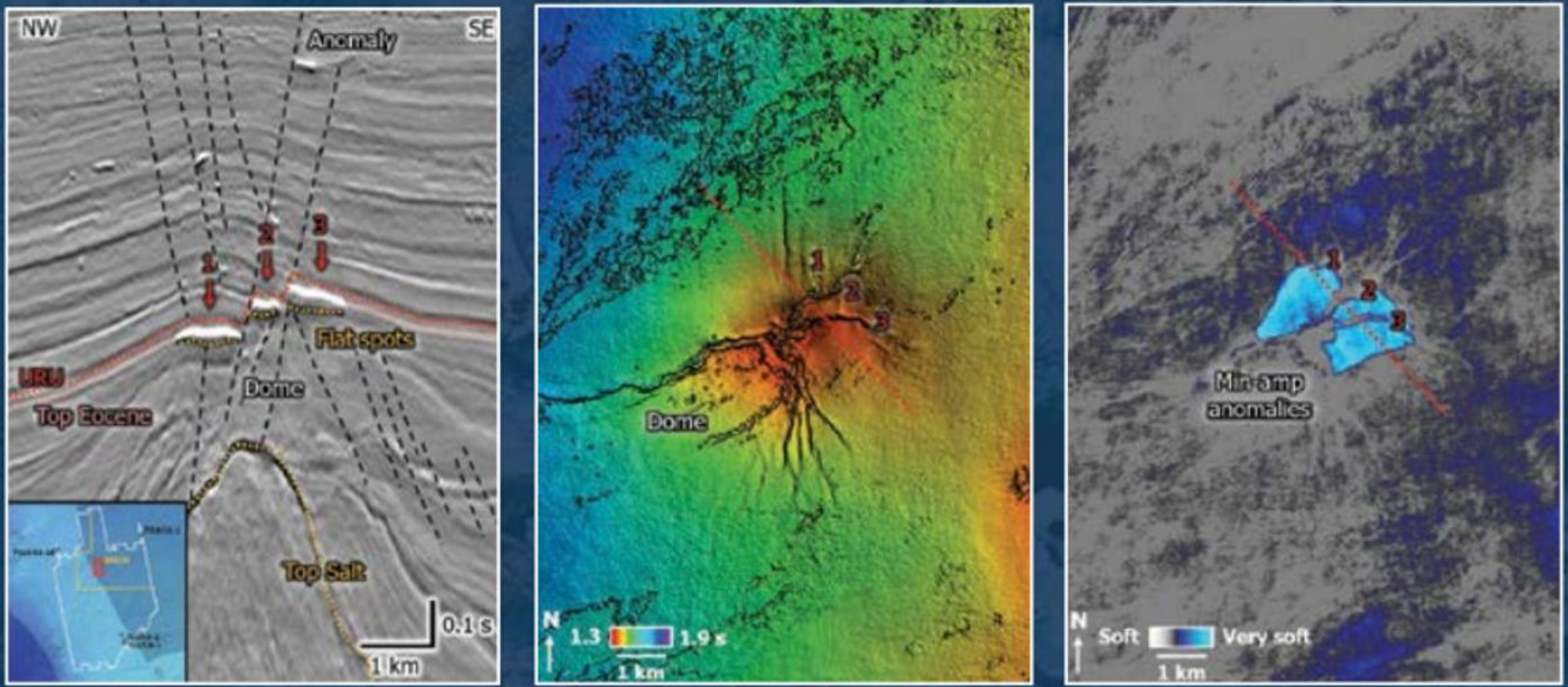
Conclusions

- The very high quality 3D dataset, together with 2D regional profiles, potential field data and wells constrain led to the detailed interpretation in the southern Sørvestsnaget Basin of 3 salt structures with a total area of 778 km^2.

- The high complexity of the salt structures -highlighted by 3D visualization and seismic attributes- has been reconducted to the intense and multi-phase tectonic movements of this basin.

- The first growing phase of the salt structures analyzed in this work show a contemporaneity with the opening of the North Atlantic and the strong crustal faults activity in the Sørvestsnaget Basin, suggesting the presence of a first phase of reactive diapirism in the area. Salt movement is however active up to 20k years ago and is probably the result of later movement of the tilted blocks -with consequent gravity gliding- and differential loading due to the thick glacial sedimentary wedge.

From subsurface interpretation to high-quality imaging, TGS has it covered.



Late Eocene | Dome Above Salt

For the last 20 years TGS and VBPR have worked together to unravel the prospectivity of volcanic margins around the world. Whether you wonder about the potential of the West Barents Sea, oil and gas plays along the Atlantic Margin, or increased exploration success in frontier basins worldwide, TGS and VBPR provide the most reliable geological, geophysical and geochemical understanding of the overburden.