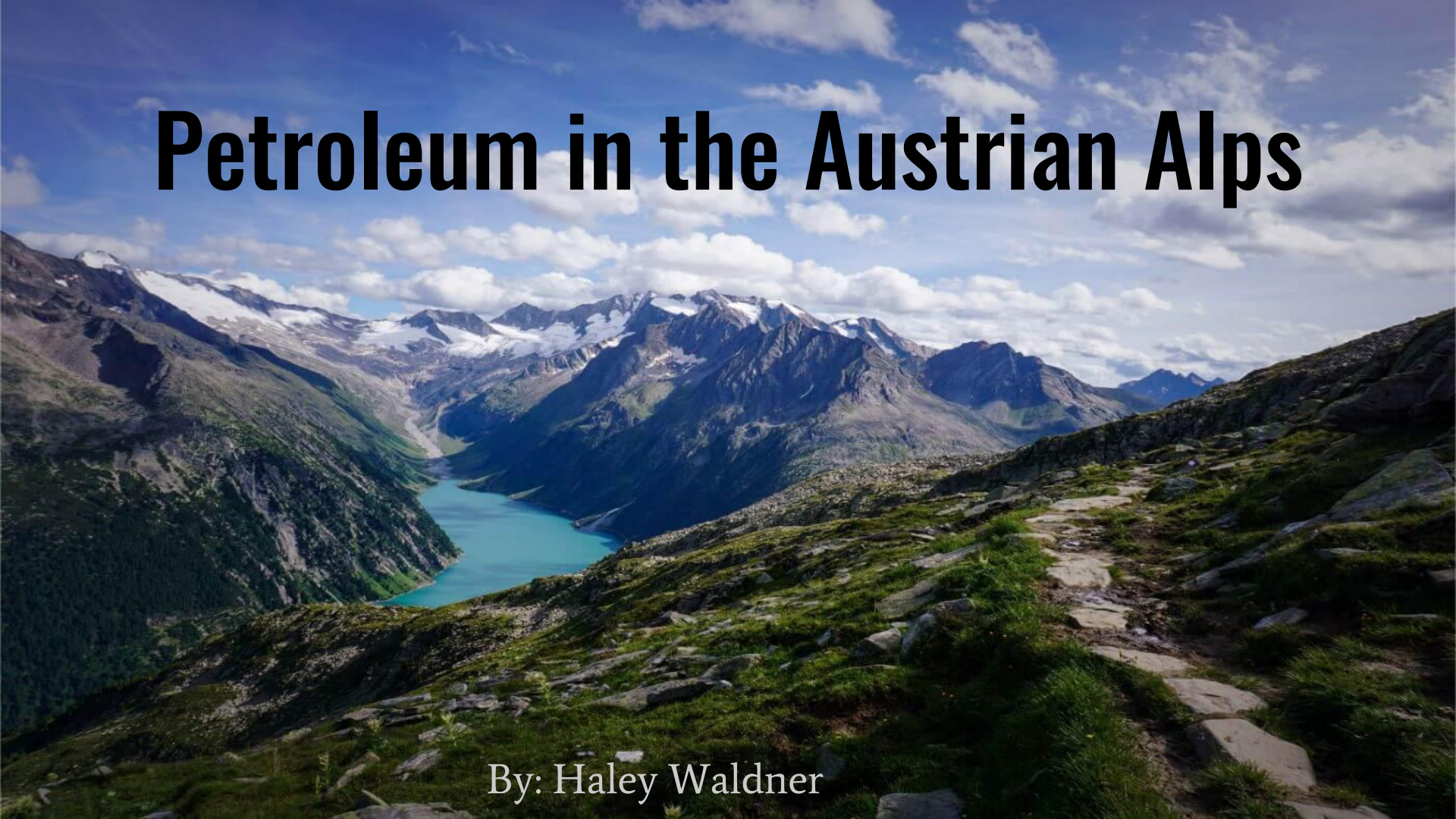
Petroleum in the Austrian Alps



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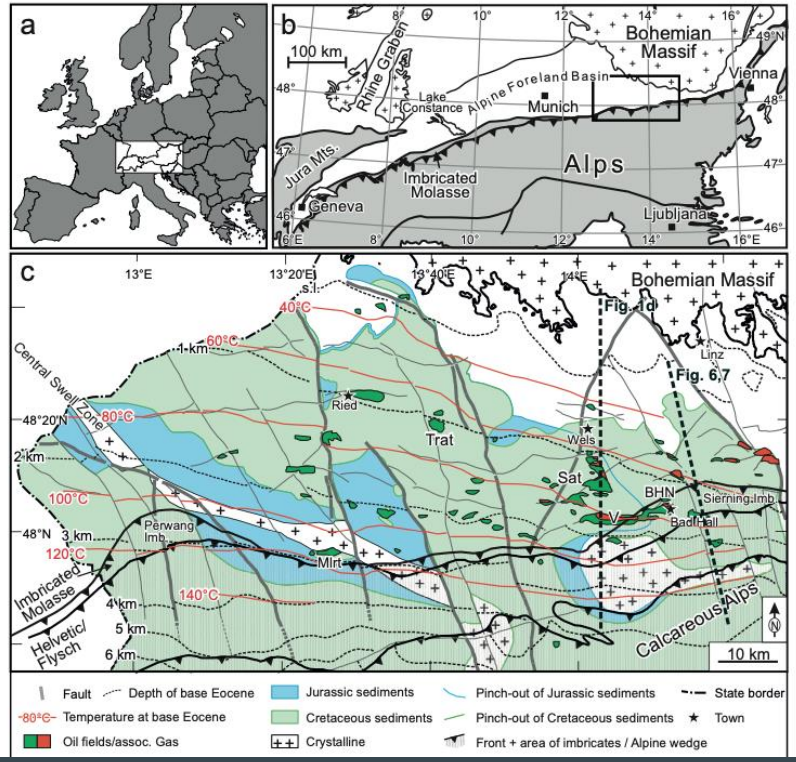
Introduction

- Brief History
- 2 Petroleum systems
  - Thermogenic
  - Microbial
- Source
- Reservoir
- Seals
- Traps
- Maturation
- Migration
- Alteration
- Summary



Brief History of the North Alps Foreland Basin

- Variscan Orogeny
  - Late Paleoszoic
  - Continental collision between Euramerica and Gondwana to form the supercontinent of Pangaea
  - Late stages produced grabens
- Grabens filled with Tropical sediments
- Major Cenomanian Transgression
  - Caused deposition of storm influenced, shallow marine, fine to coarse grained glauconitic (Iron and potassium rich) sandstone
- Series of marine depositions and clay layers through the oligocene and miocene produce bulk of gas and oil

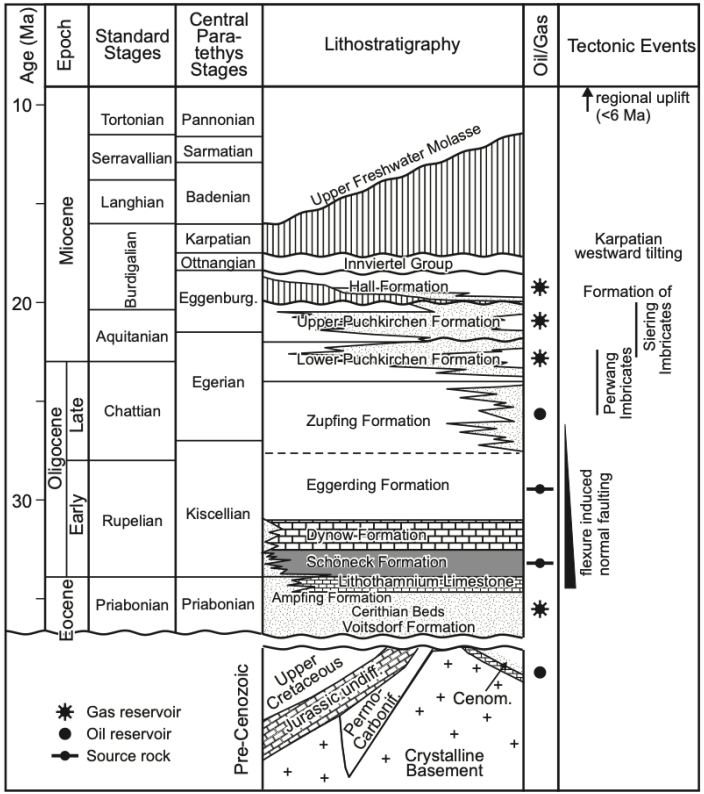


Fig. 2. Lithostratigraphy of the Austrian part of the North Alpine Foreland Basin with the main source and reservoir rocks (modified after Wagner, 1998; Hinsch, 2013; and Grunert *et al.*, 2015). Timing of Cenozoic tectonic events after Gusterhuber *et al.*, 2012; and Hinsch, 2013.

Thermogenic System

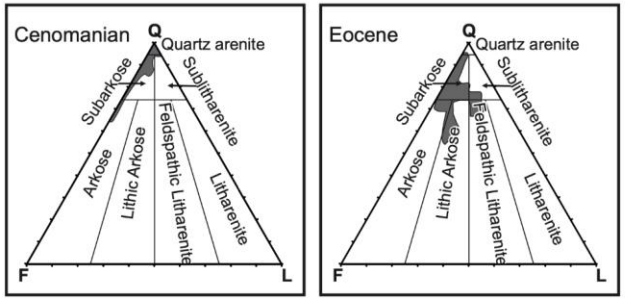


Fig. 5. QFL classification (Folk, 1968) of Cenomanian and Eocene reservoir sandstones (Q – quartz; F – feldspar; L – lithic fragments).

- Source Rocks-
  - Schöneck formation- biggest producer
    - 10-25m thick marls
  - Dynow and Eggarding- smaller but still organic rich
    - Dyndow- 5-15m thick marls
    - Eggarding- moderate organic matter
- Reservoir rocks-
  - Upper Eocene Sandstones
    - Bulk of oil
    - Coarse grained and matrix poor as well as tidal and shallow marine sandstones
    - Up to 25% porosity and up to 3000mD permeability
  - Mesozoic Sandstones (Cenomanian)
    - Some oil occurs
    - Coarse grained and matrix free storm deposits form the best of these reservoirs
    - 8-26% porosity and ranges <1-over 3000 mD permeability

Marl or marlstone is a carbonate-rich mud or mudstone which contains variable amounts of clays and silt (piles of eroded sediment)

Thermogenic System

- Seals
  - Eocene
    - Sealed by shales and peltic rocks
  - Mesozoic
    - Sealed by marlstone and mudstones
      - Between 0-750m in thickness
  - The principal seal rock of the basin is fine grained Oligocene and Miocene rocks that are 100’s of meters thick.
- Traps
  - Principally structural traps due to faulting (pinching out)
  - Formation occurred during the Oligocene when normal faults were partially inverted during the Alpine orogeny

Thermogenic Systems

- Thermal Maturation and Hydrocarbon Generation
  - Generation began due to deep burial in the early Miocene and resulted in increased temperature of the source rock
  - Uplift and erosion in the late Miocene cooled and ended hydrocarbon generation
- Migration
  - Generation and migration started simultaneously
  - Models indicate liquid hydrocarbons migrated along the source rock until they reached a fault leading to the Mesozoic and Eocene Sandstone Units
- Alteration
  - Biodegradation- results in the formation of heavy oil
  - Water Washing- removal of light hydrocarbons with higher solubility
  - Asphaltene Precipitation- natural deasphalting of oil creates tar which impedes usage

Microbial Petroleum System

- Source rocks
  - Siliciclastic reservoir rocks and peltic intervals in the Puchkirchen Group and the Hall formation
  - Due to shallow burial the organic matter in these formations is immature
  - Biomarker analysis suggests predominantly terrigenous organic matter deposited in a moderately salient marine basin.
- Reservoir rocks
  - Sandstones and Sandy Conglomerates deposited in a channel belt
  - Typically occur in stacked turbidite beds with a thickness of 0.1-2 m
  - Porosity up to 30% and permeability 100- over 1000 mD

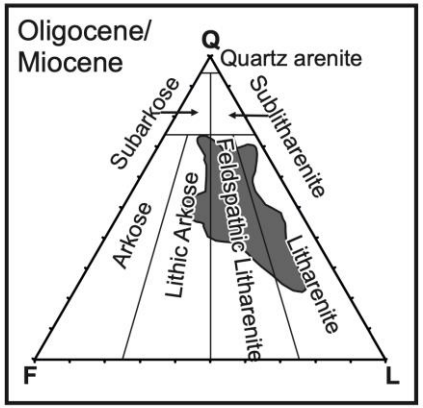


Fig. 12. QFL classification (Folk, 1968) of Oligocene/ Miocene reservoir sandstones from the Austrian part of the North Alpine Foreland Basin (Q – quartz; F – feldspar; L – lithic fragments).

Microbial Petroleum System

- Seals
  - Coarse grained reservoir rocks are isolated by pelitic sediments
  - Intercalation (interbedding) of shale and sandstone
- Traps
  - Generally accumulates in a broad, low relief anticline
  - Some accumulation in stratigraphic traps, primarily pinch outs
- Hydrocarbon Generation
  - Isotopically light methane is believed to be of microbial origin
  - Decomposed organic matter due to fermentation and CO_2 reduction
  - Methane dissolved into pores until saturation was reached then generated in a free gas phase

A pelite or metapelite is a metamorphosed fine-grained sedimentary rock, i.e. mudstone or siltstone.

Microbial Petroleum System

- Hydrocarbon Mixing and Biodegradation
  - Very dry microbial gas
    - Only small amounts of ethane and propane
    - Lower ratios of stable carbons
  - Mixing of microbial and thermogenic petroleum systems is evident based on the condensates
    - Condensates are products of evaporative oil fractonation
  - Biodegradation
    - Resulted in gas drying
    - Presence of Ethane and Propane suggest Biodegradation is still occurring presently

Summary

- The North Alpine Foreland Basin is a smaller hydrocarbon province
- There are 2 Petroleum production systems
  - Thermogenic
  - Microbial

Questions?

Sources

- https://people.wou.edu/~taylors/es486_petro/readings/Gross_et_al-2018.pdf
- Picture of alps- https://www.moonhoneytravel.com/europe/austria/hiking-austrian-alps/