Integrating Geological Processes and Petrophysics in Carbonate Reservoir Rock Typing*

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Abstract

Porosity distribution in carbonate petroleum reservoirs is commonly controlled by a combination of factors, including depositional texture, geochemical and mechanical processes. Without a clear knowledge of these parameters, the prediction of reservoir properties is speculative. Reservoir models often require the implementation of permeability-modifying coefficients to match the actual reservoir behaviour during production. The discrepancy between predicted and actual reservoir behaviour is usually poorly understood, arguably in large part because a strong, geological process-driven model is missing.

This study provides an innovative methodology to understand what has spatially and temporally controlled the distribution of porosity by back-stripping pore evolution and defining diagenetically-controlled pore fabrics. Importantly, the methodology relies on a sedimentological and structural framework which should be in place prior to such study. First, pore types and cement types should be quantified and the relationship between these parameters, lithofacies and reservoir quality should be analysed. Second, a pore fabric scheme, which considers the depositional texture, pore types and shapes and the impact of pore-filling cements should be established in order to combine these parameters in a practical manner. Third, mapping the distribution of open and cemented porosity at several key stages of the burial history and the final distribution of pore fabrics should provide the framework in which the diagenetic reconstruction can be implemented. Finally, by combining the diagenetic model and the mapped pore-fabric distribution, petrophysical rock types can be defined that honour those geological process that led to the

formation of the final pore network. The methodology is introduced here using a virtual database but was previously tested on a multiscale, multimodal pore network (Lower Cretaceous oil reservoir, Middle East).

Selected References

Anselmetti, F.S., S. Luthi, G.P. Eberli, 1998, Quantitative characterization of carbonate pore systems by digital image analysis: AAPG Bulletin, v. 82/10, p. 1815-1836.

Clark, D.N., 1986, The Distribution of Porosity in Zechstein Carbonates: Geol. Soc. London Special Publications, v. 23/1, p. 121-149.

Saller, A.H., J.A.D. Dickson, and F. Matsuda, 1999, Evolution and distribution of porosity associated with subaerial exposure in upper Paleozoic platform limestones, West Texas: AAPG Bulletin v. 83/11, p. 1835-1854.

Sharland, P., R. Archer, D.M. Casey, and M.D. Simmons, 2001, Arabian Plate Sequence Stratigraphy: GeoArabia Special Pub. 2.

van Buchem, F.S.P., M. Al-Husseini, F. Maurer, and H. Droste, 2010, Aptian stratigraphy and petroleum habitat of the Eastern Arabian Plate: GeoArabia Special Publication 4.

van Buchem, F.S.P., N. Svendsen, E. Hoch, R. Pedersen-Tatalovic, and K. Habib, 2014, Depositional history and petroleum habitat of Qatar, *in* L. Marlow, C.C.G. Kendall and L.A. Yose, Eds., Petroleum systems of the Tethyan region, AAPG Memoir 106, p. 641-678.

Warrlich, G., C. Taberner, W. Asyee, and J.-H. van Konijnenburg, 2010, The impact of post-depositional processes on reservoir properties: Two case studies of Tertiary carbonate buildup gas fields in Southeast Asia (Malampaya and E11), *in* Cenozoic Carbonate Systems of Australasia, SEPM Special Pub. 95, p. 99-127.

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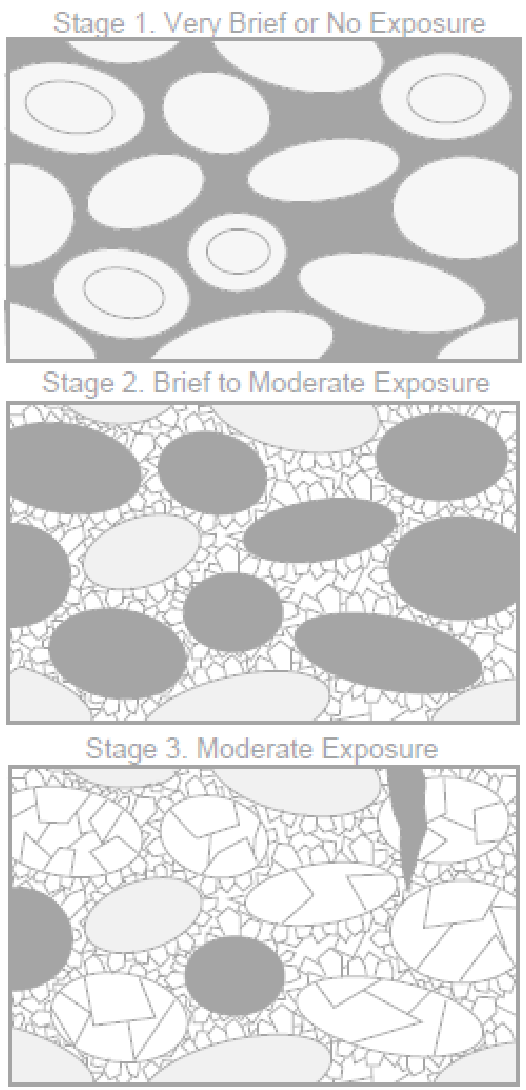
Reservoir modeling

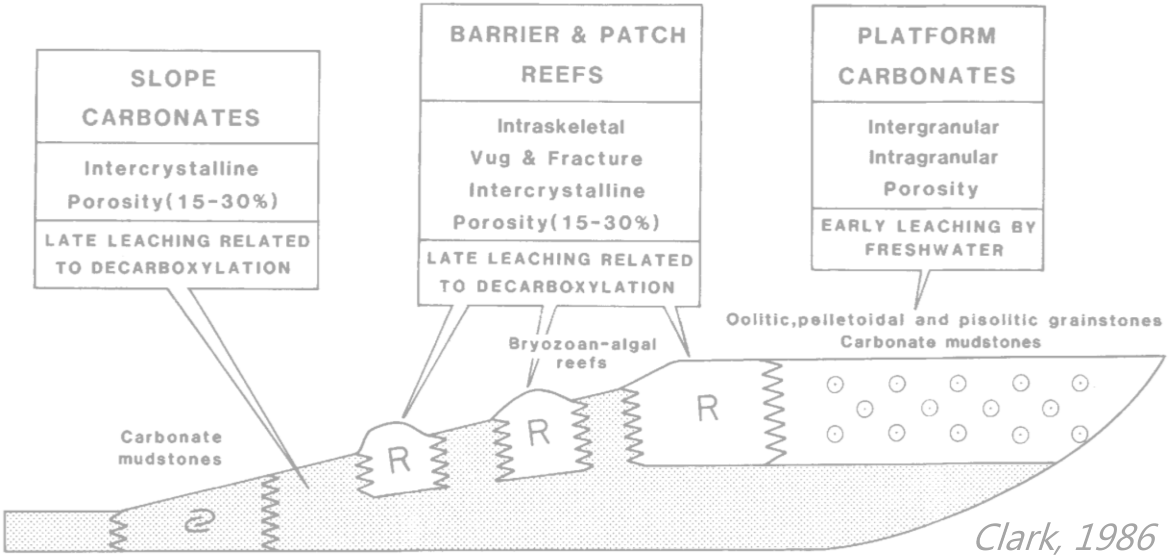
- Reservoir models must combine
  - Geology, inc. rock types, microfacies, depositional architecture
  - Petrophysics, inc. porosity and permeability
- How to combine geology and petrophysics?
  - In siliciclastic reservoirs: *fairly simple* stratigraphic framework, with poro-perm values integrated into each facies
  - In carbonate reservoirs:

Two approaches: (1) Geological processes



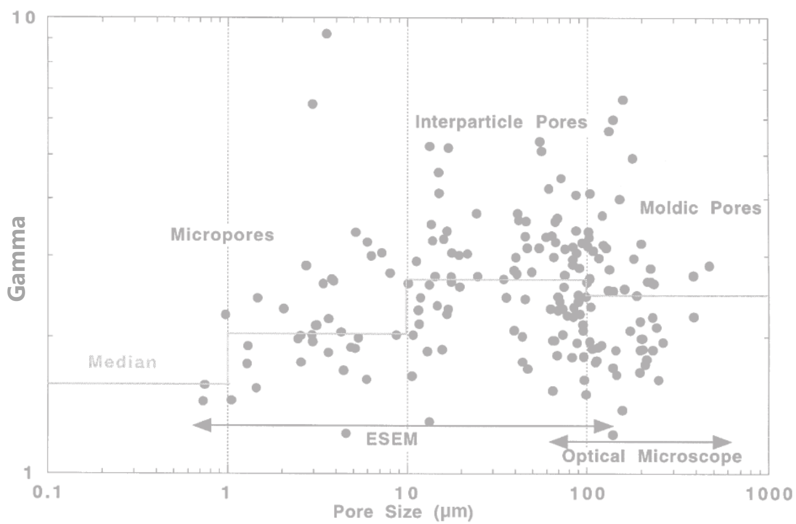
Saller et al. 1999

- Descriptive, artistic
- Understands causes and effects
- ➢ How to implement into reservoir model??



Clark, 1986

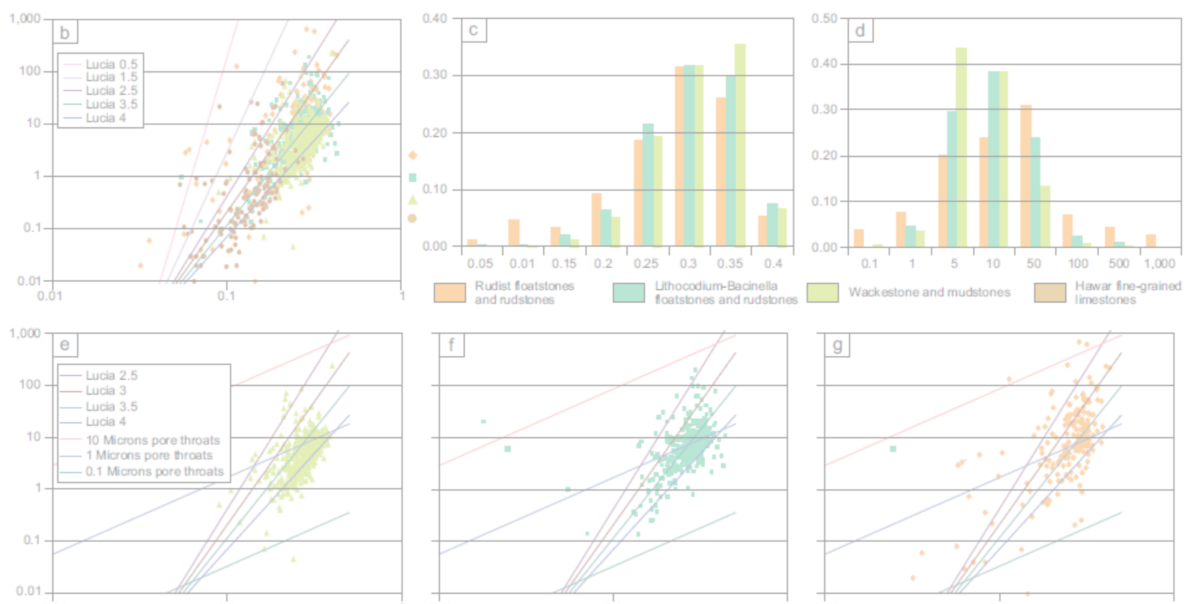
Two approaches: (2) Petrophysical, data-based



Anselmetti et al. 1998

- Quantitative, statistical
- Easy to implement into reservoir model (rock typing)

➢ Ignores geological causality



Warrlich et al. 2010

How to combine both approaches…

Results

Diagenetic framework
- Petrography
- Geochemistry
- Fluid inclusions
- Relation with facies and pore types
- Distribution (map)

Pore types
- Morphology
- Relation with facies and cements
- Distribution (map)

Background and parallel studies

Setting:
- Tectonism
- Burial
- Hydrology
- Geochemistry

Petrophysics, e.g.
- Porosity
- Permeability

Depositional framework
- Lithology
- Microfacies
- Distribution (map)

Interpretations

Paragenetic evolution
- Origin and distribution of cements and pores at different burial stages

Pore fabrics
- Reservoir quality

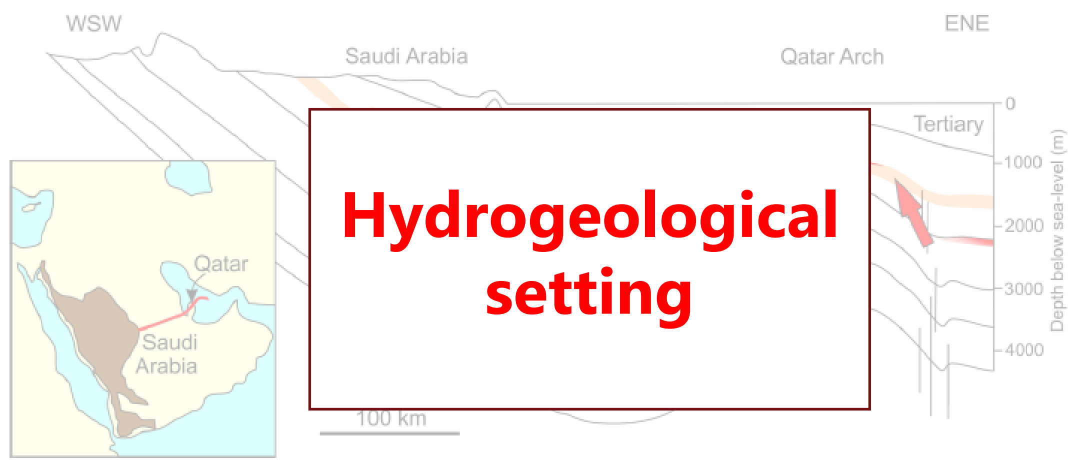
Model

Rock-typing scheme

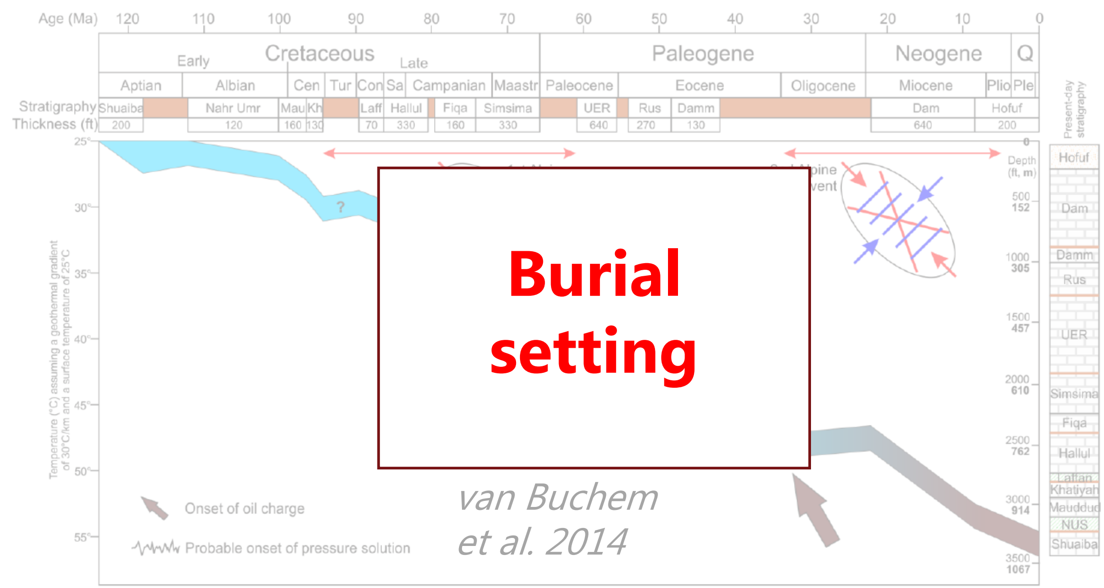
Background: Setting

Tectonic setting

Sharland et al. 2001



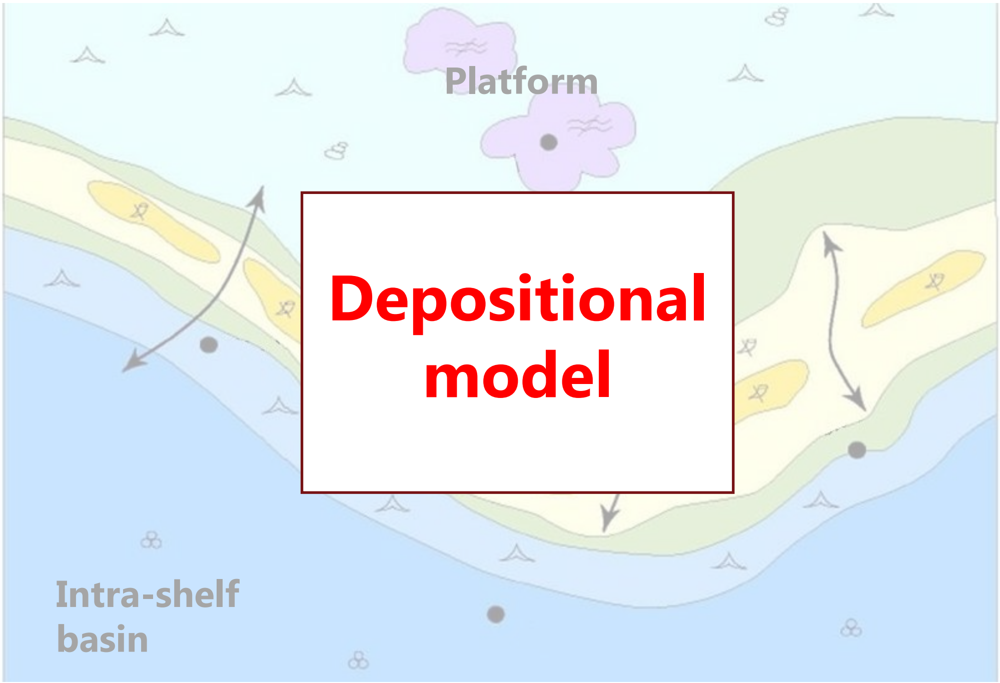
Hydrogeological setting



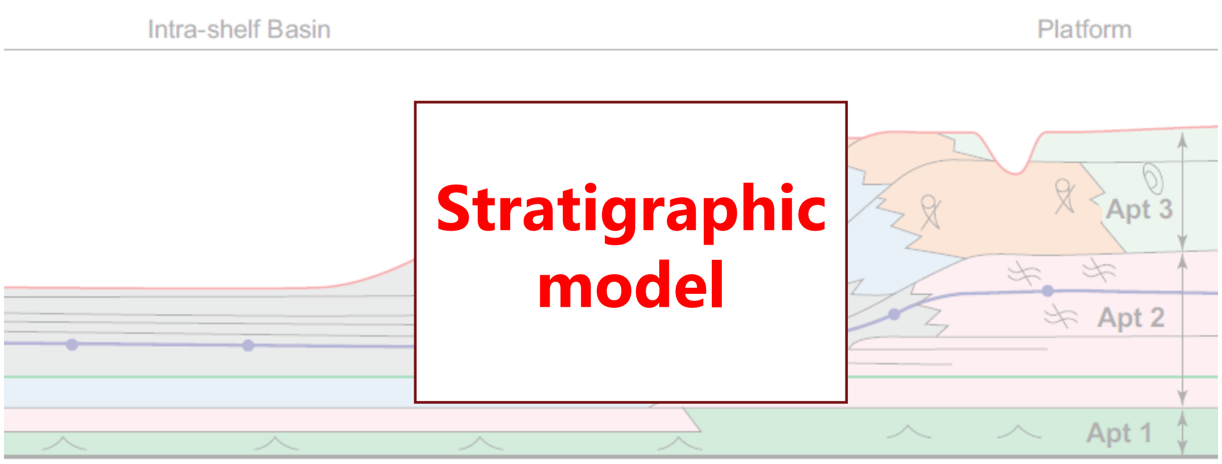
Burial setting

van Buchem et al. 2014

Background: Stratigraphic framework

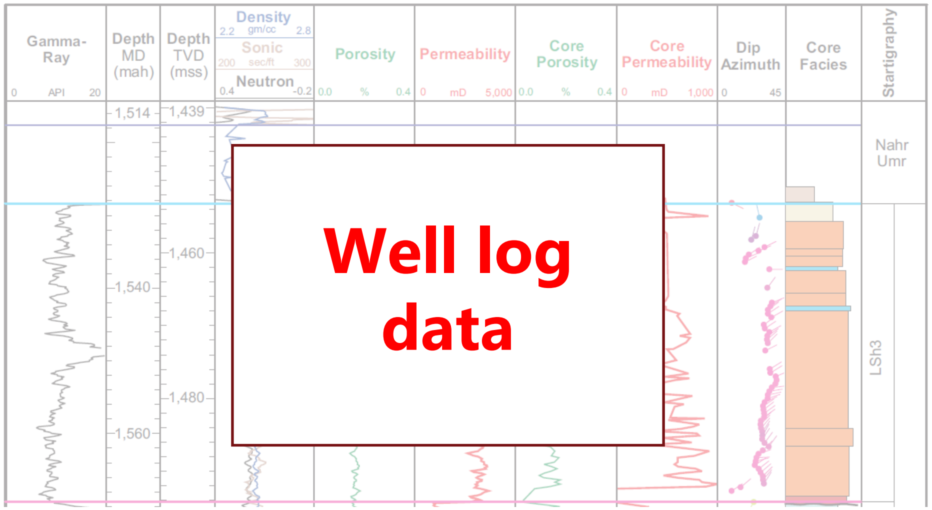


van Buchem et al. 2009

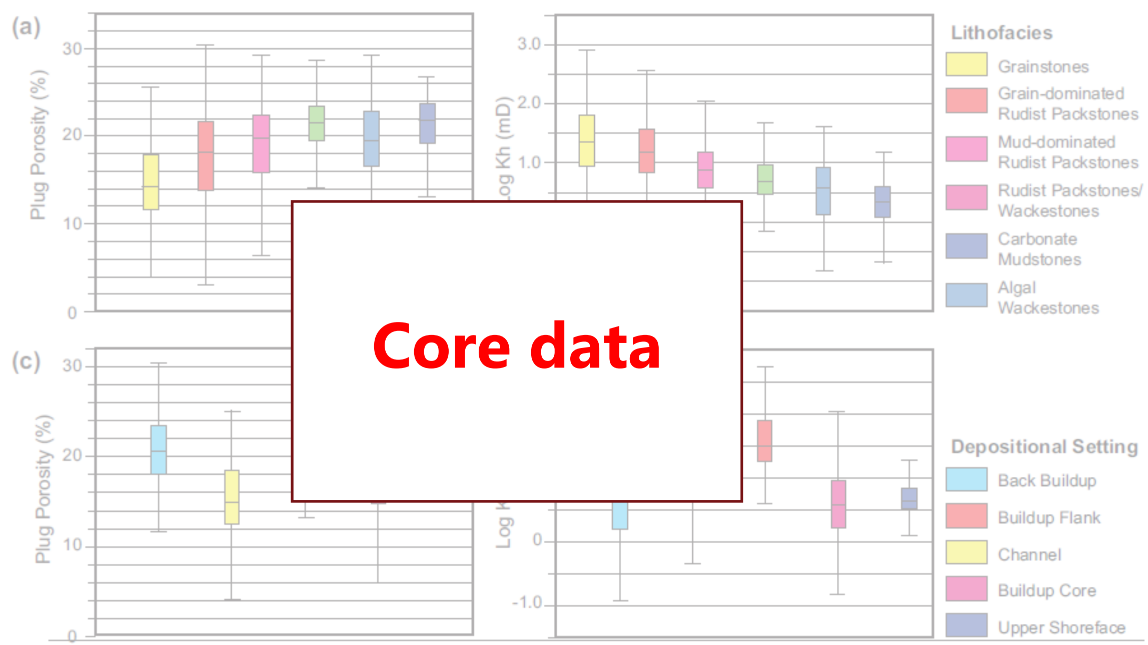


van Buchem et al. 2010

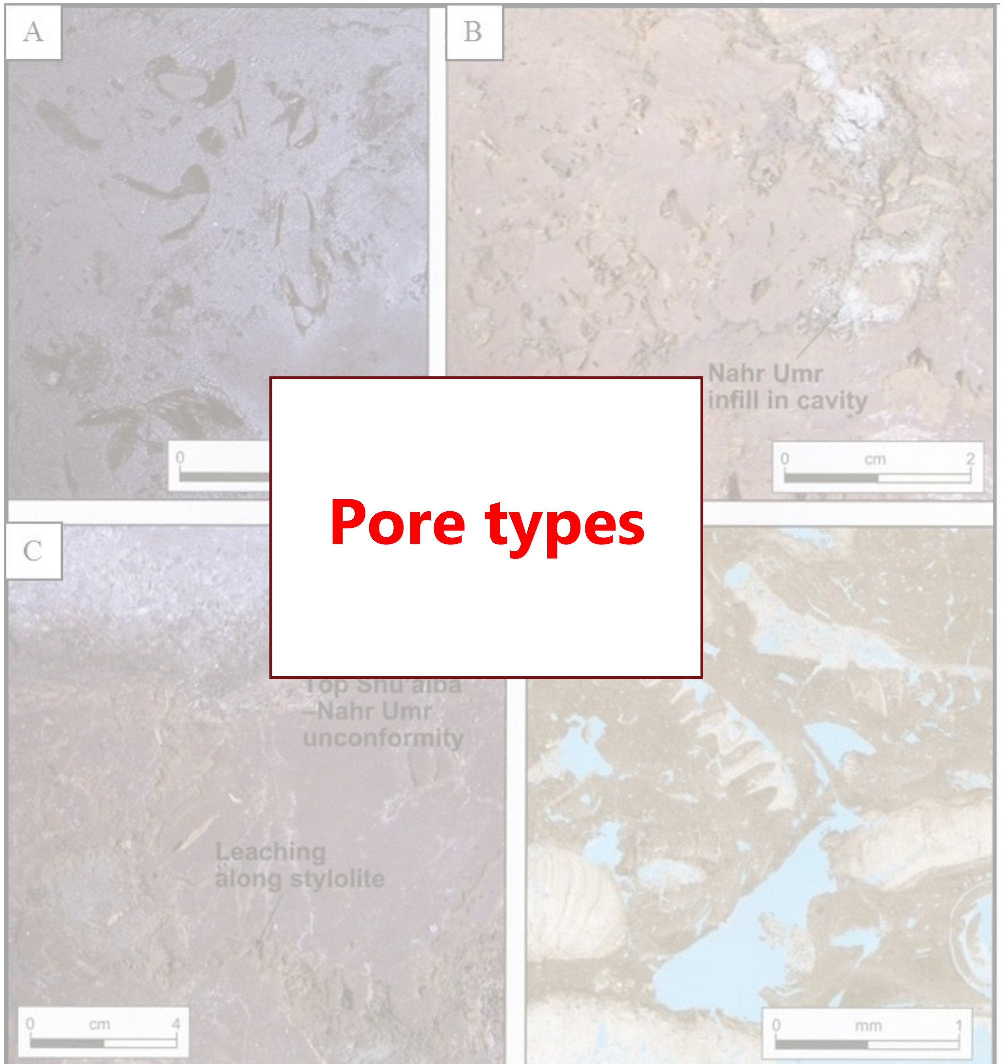
Background: Petrophysics



Amthor et al. 2010

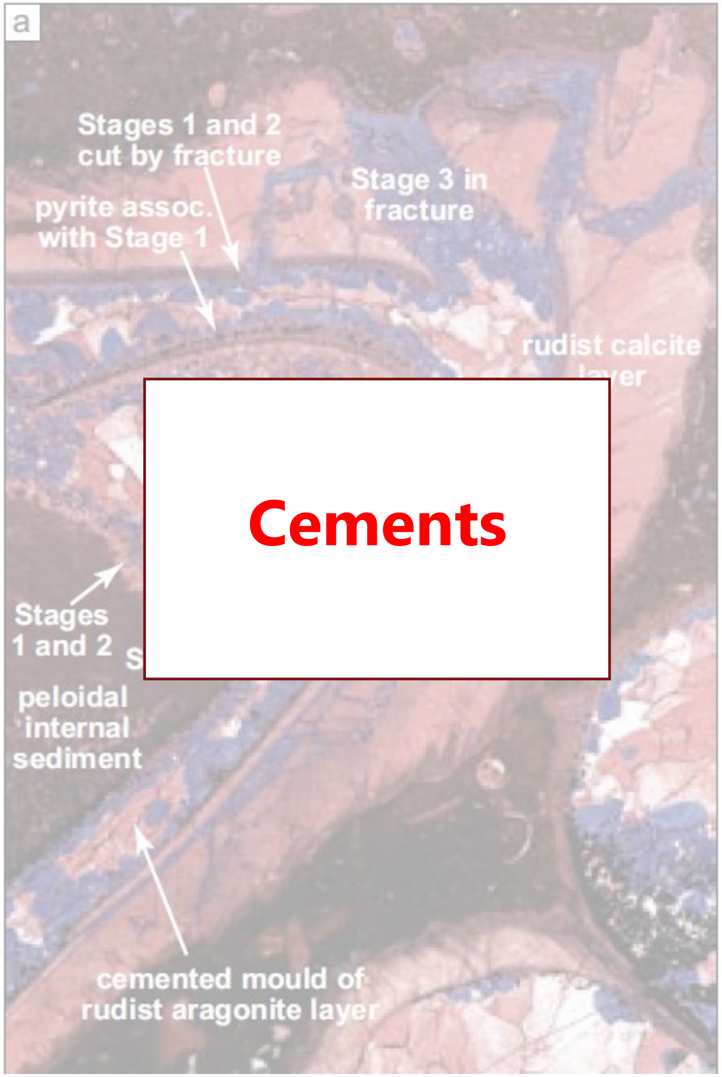


Results: Cements and Pore types



Pore types

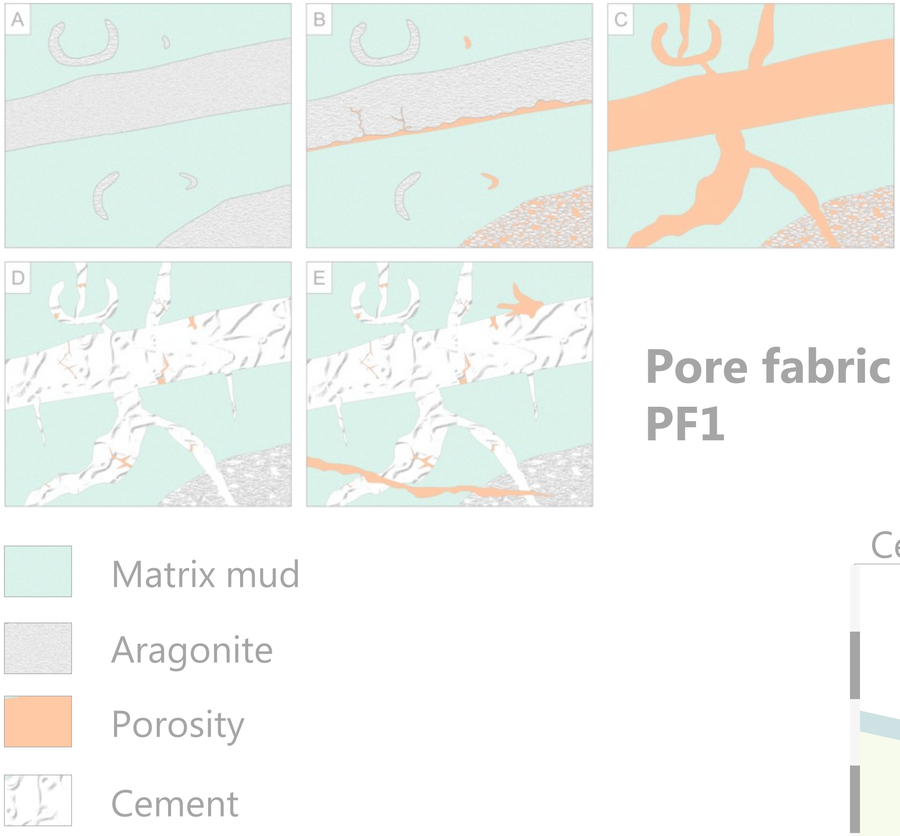
Warrlich et al. 2010



Cements

Raven and Dickson 2007

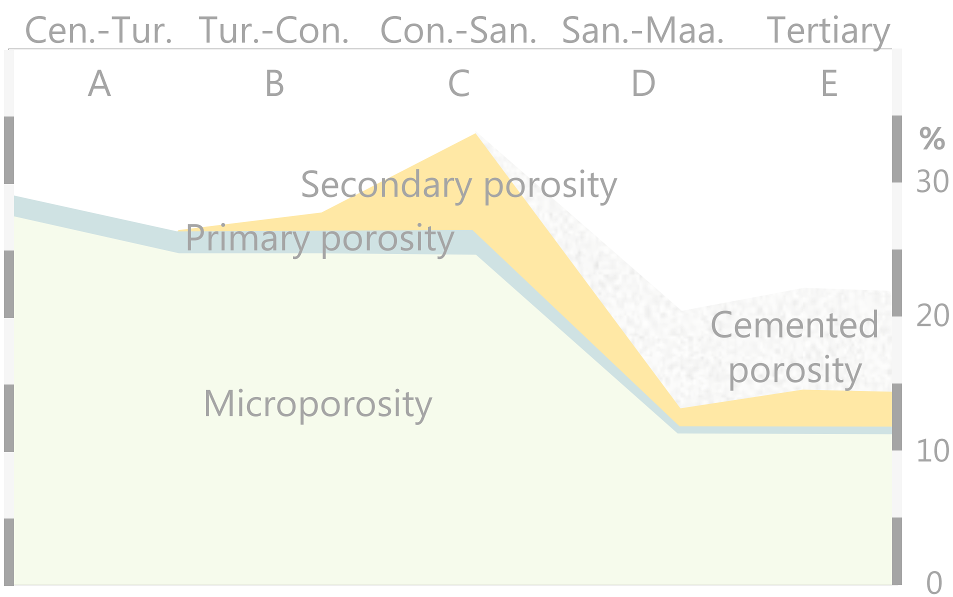
Interpretations: Pore fabrics



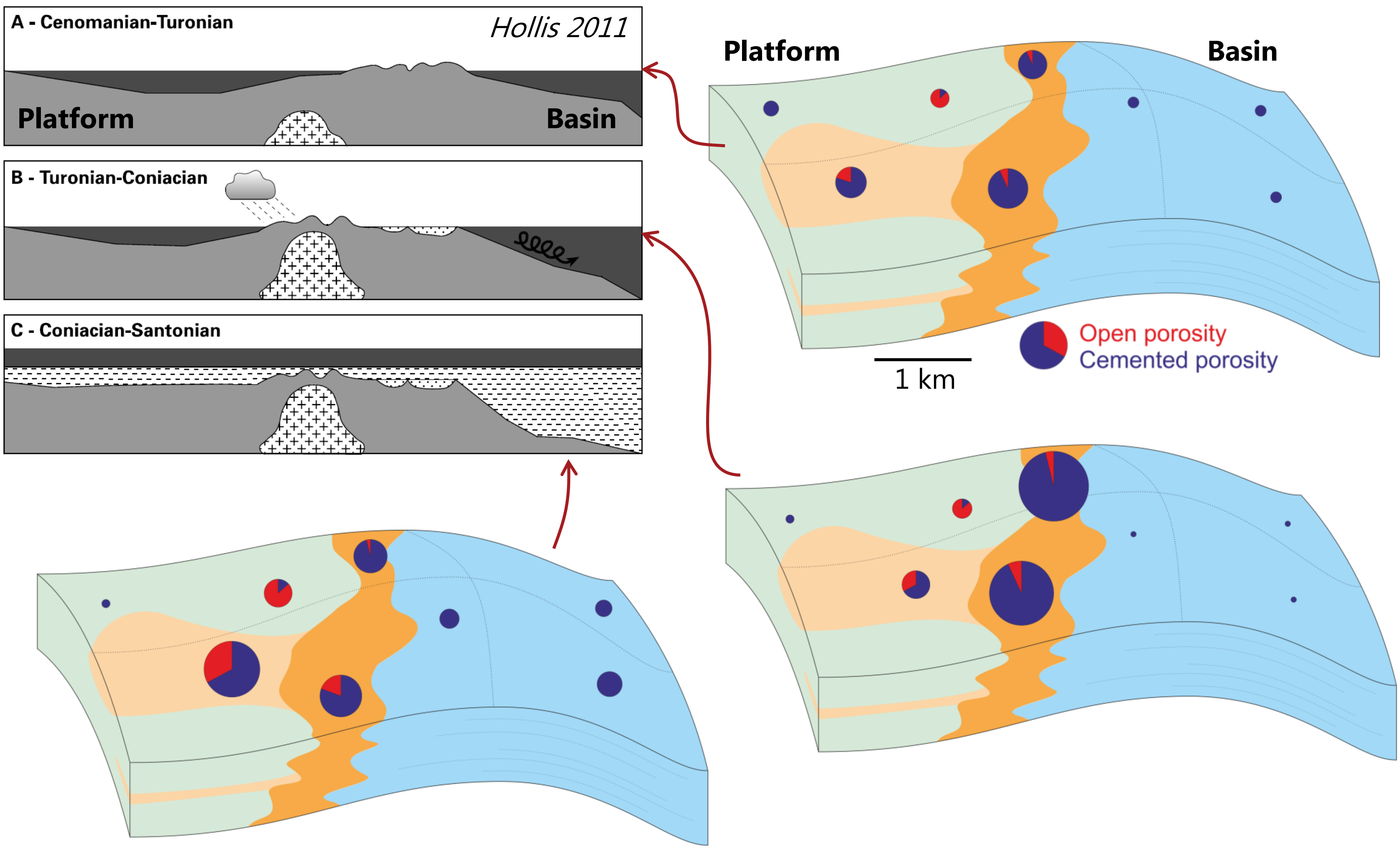
Pore fabric PF1

Pore fabrics incorporate:

- Petrophysics: pore geometry, plug data, MICP
- Diagenetic history, i.e. dissolution-cementation processes

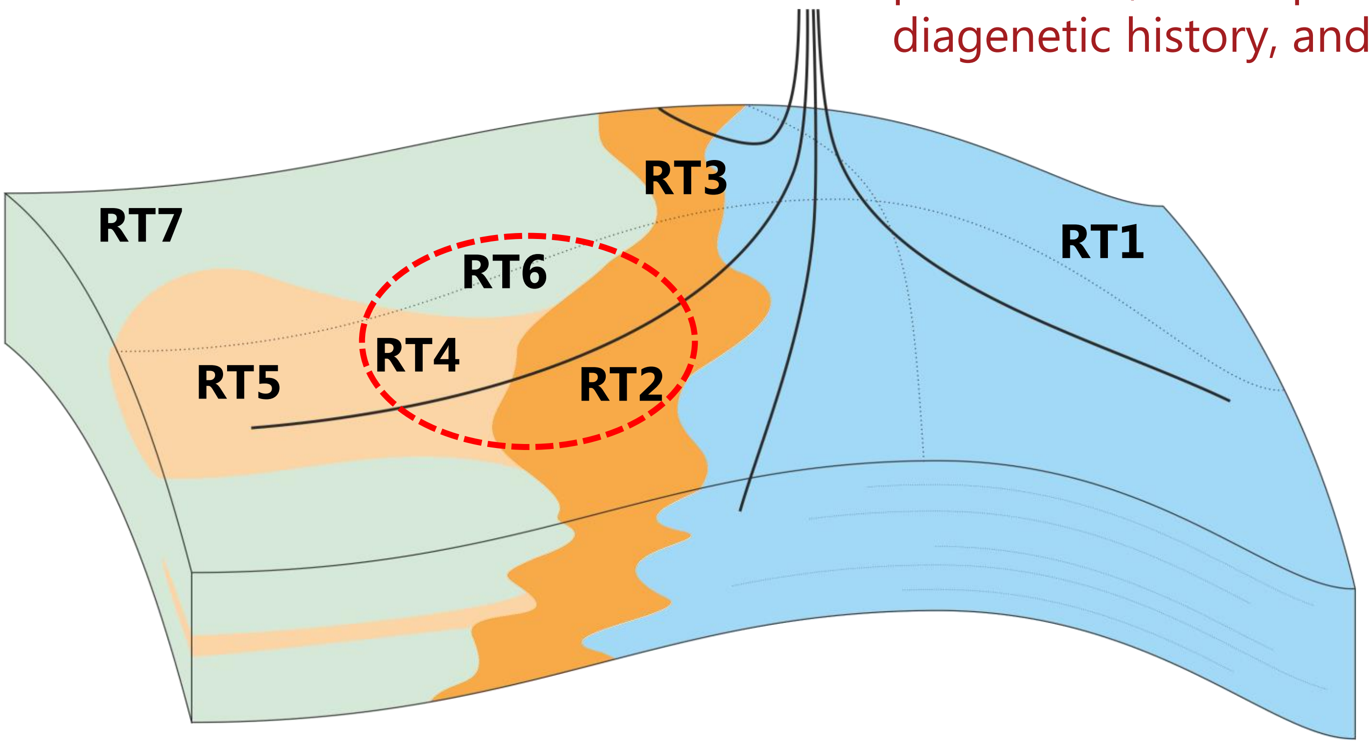


Interpretations: Spatial paragenetic evolution



Rock-typing scheme and distribution

- Pore fabrics are combined with depositional model
  - ➢ Rock types honour all geological parameters, inc. depositional facies and diagenetic history, and petrophysical data



	Ø (%)	K (md)
RT1	High	Low
RT2	High	High
RT3	Low	Mod
RT4	High	High
RT5	Mod	Mod
RT6	High	Mod
RT7	Mod	Low