

Pressure Generation and Deflation Mechanisms in Deeply Buried Intra-Salt Reservoirs of the Late Neoproterozoic to Early Cambrian South Oman Salt Basin*

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Search and Discovery Article #41112 (2012)

Posted December 31, 2012

*Adapted from extended abstract prepared in conjunction with oral presentation at AAPG International Conference and Exhibition, Singapore, September 16-19, 2012, AAPG©2012. Please see closely related article, [“An Integrated, Multi-scale Approach to Salt Dynamics and Internal Dynamics of Salt Structures”, Search and Discovery article #40703.](#)

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Abstract

Late Neoproterozoic to early Cambrian intra-salt Ara reservoirs of the South Oman Salt Basin represent a unique self-charging petroleum play with respect to hydrocarbon and overpressure generation and dissipation. Reservoir bodies (termed "stringers") are isolated in salt and frequently contain low permeable dolomites that are characterised by high initial production rates due to hard overpressures.

A database of more than 30 wells has been utilised to understand the distribution and generation of overpressures in intra-salt reservoirs that can be separated by up to 350 metres of salt. A temporal relationship of increasingly overpressured and compartmentalized reservoirs within stratigraphically younger units is observed, and two distinctly independent trends emerge from the Oman dataset; one hydrostatic to slightly above hydrostatic, and one overpressured from 17 to 22 kPa/m, almost at lithostatic pressures.

Structural, petrophysical and seismic data analysis suggests that overpressure generation is driven by fast burial of the stringers in salt, with a significant contribution by thermal fluid effects and kerogen conversion. Pyrobitumen confirms local contribution by a high-temperature hydrothermal event. Structural and geometric information indicate that present day hydrostatic stringers have been overpressured in their earlier geologic evolution. Evidence for these initial overpressures in currently hydrostatic reservoirs is provided by hydrocarbon-veined cores from halite overlying the reservoirs. Pressure deflation responsible for presently hydropressed reservoirs is conceivable by structural configurations to adjacent clastic minibasins or by further isolation and fluid injection into surrounding rock salt once minimum principle stress levels have been reached to dilate the salt. This is witnessed by black, hydrocarbon-stained cores of Ara salt directly above and below some of the stringer reservoirs. Pressure generation and deflation mechanisms are controlled by salt tectonic, microstructural (grain

boundary network) and thermo-kinetic (burial and kerogen conversion) constraints and parameters. The processes revealed in this study are considered significant for other evaporite basins.

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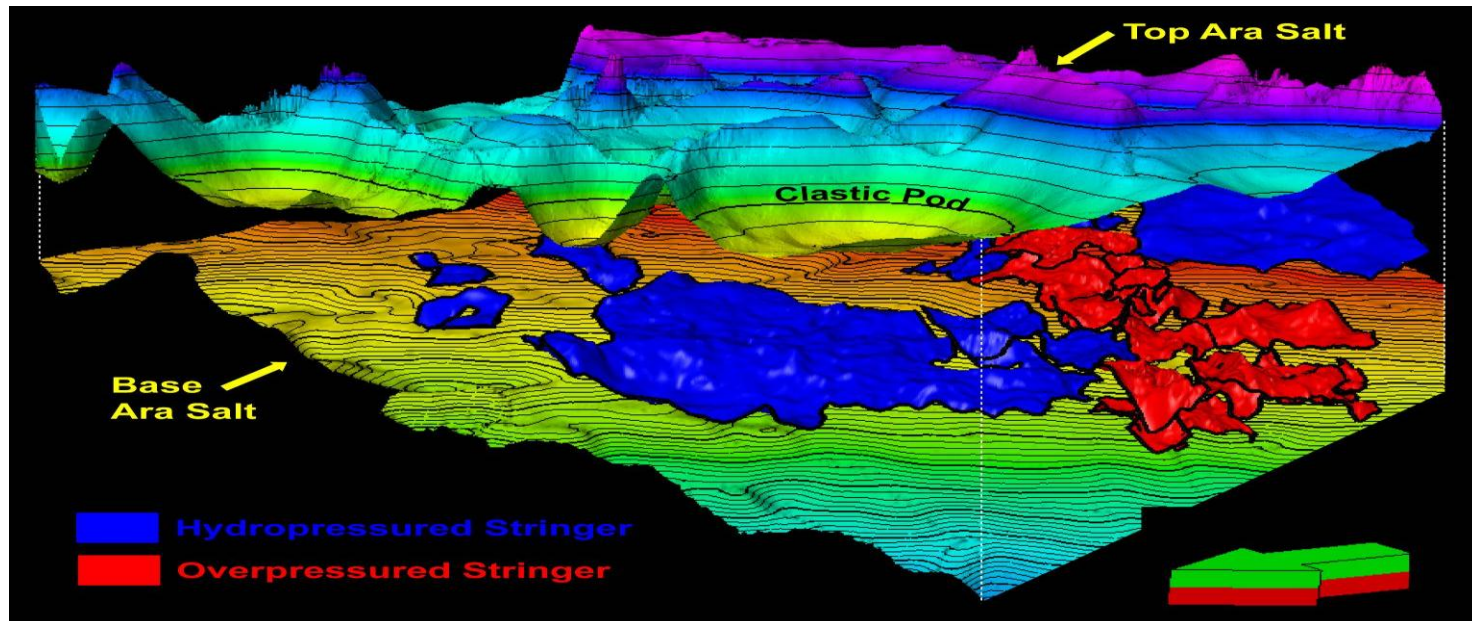
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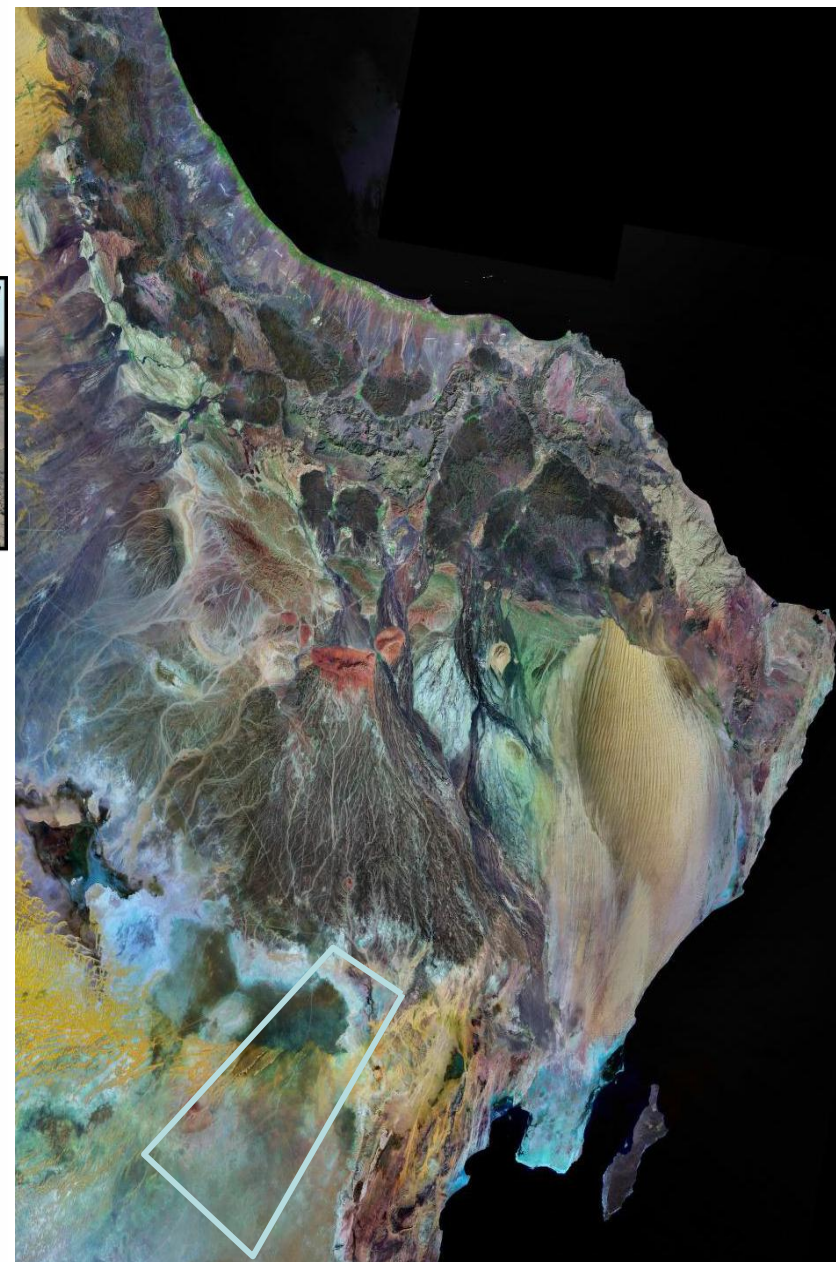
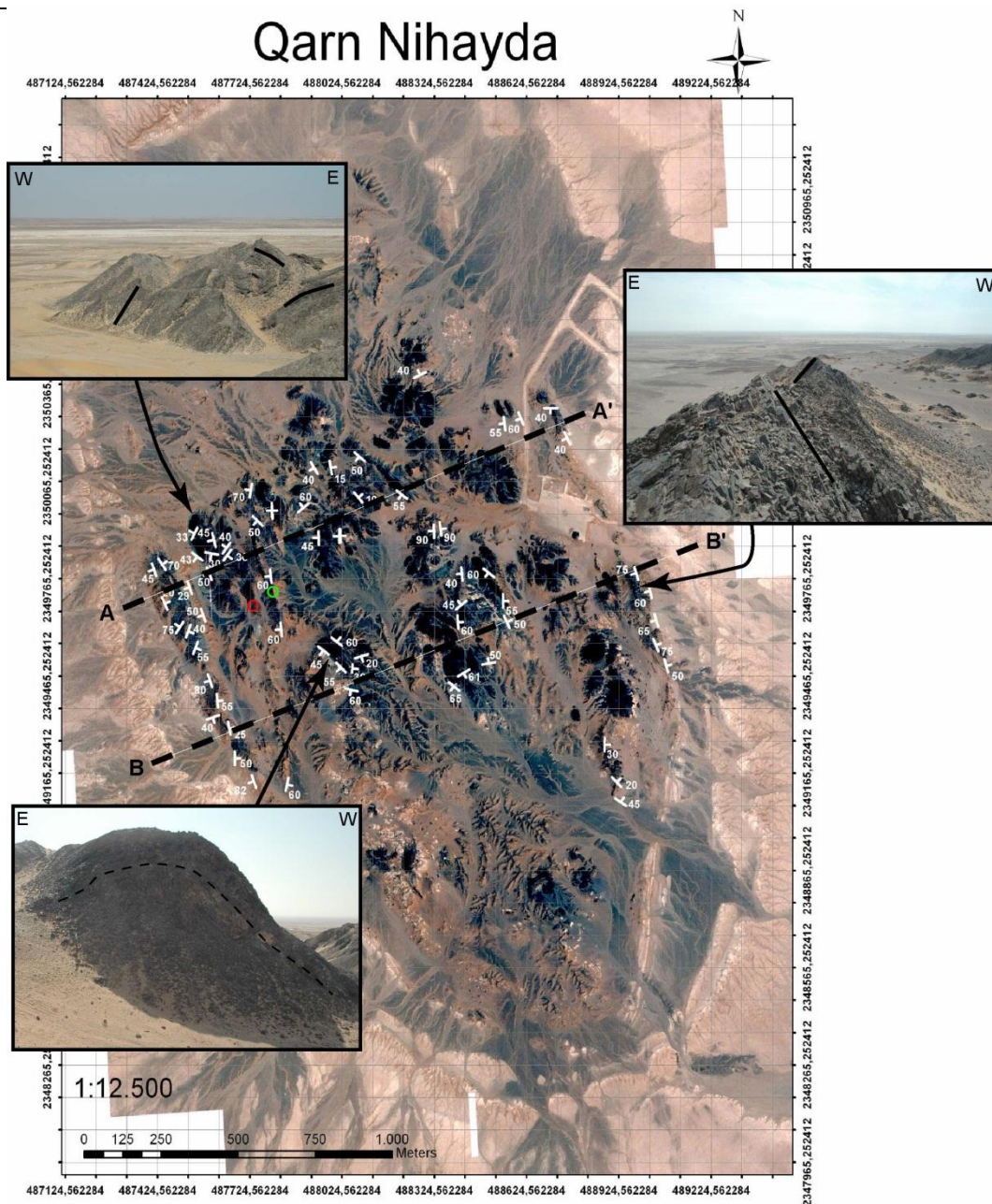
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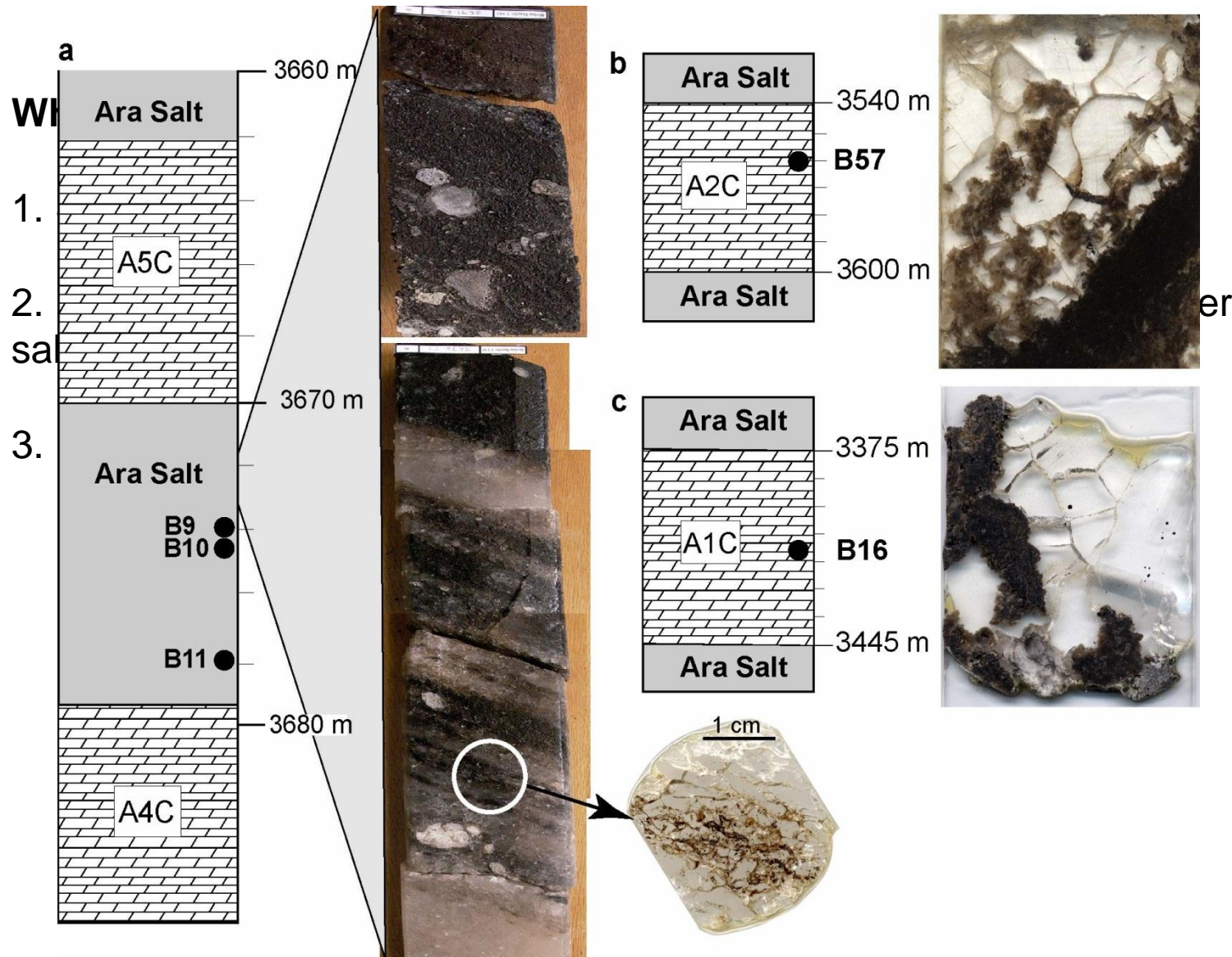


Neoproterozoic (Hormuz) Salt in Oman

Qarn Nihayda

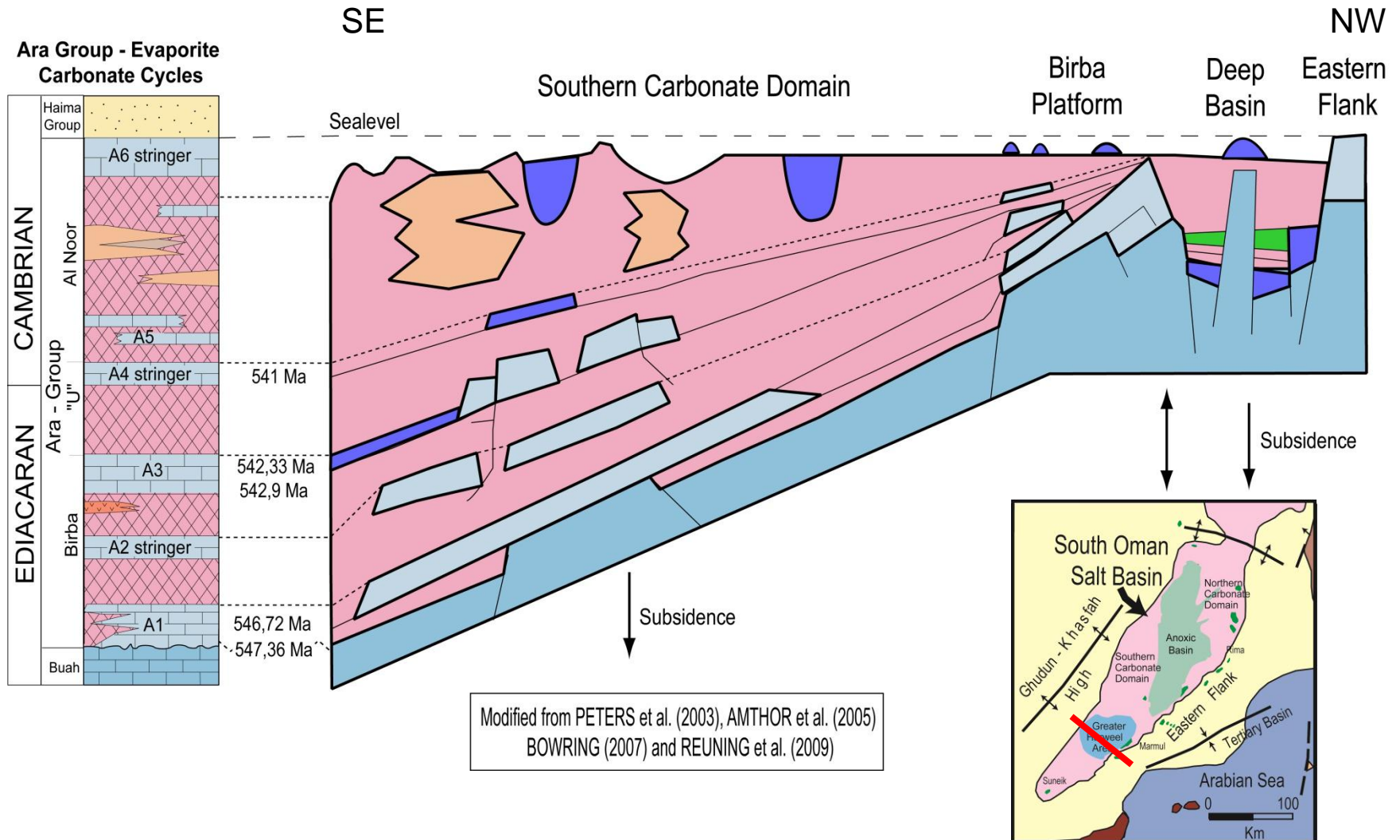


Hydrocarbons in salt

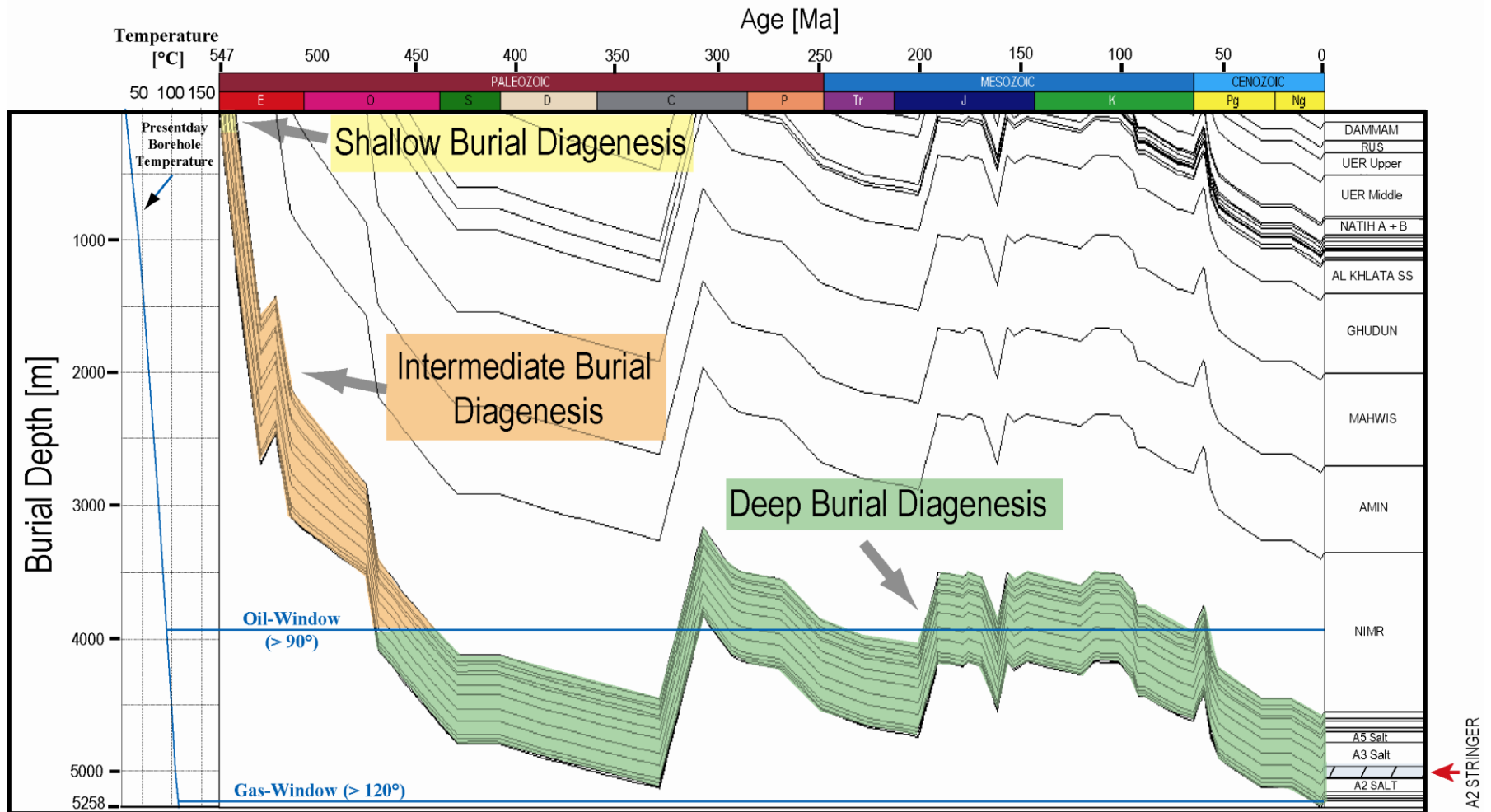


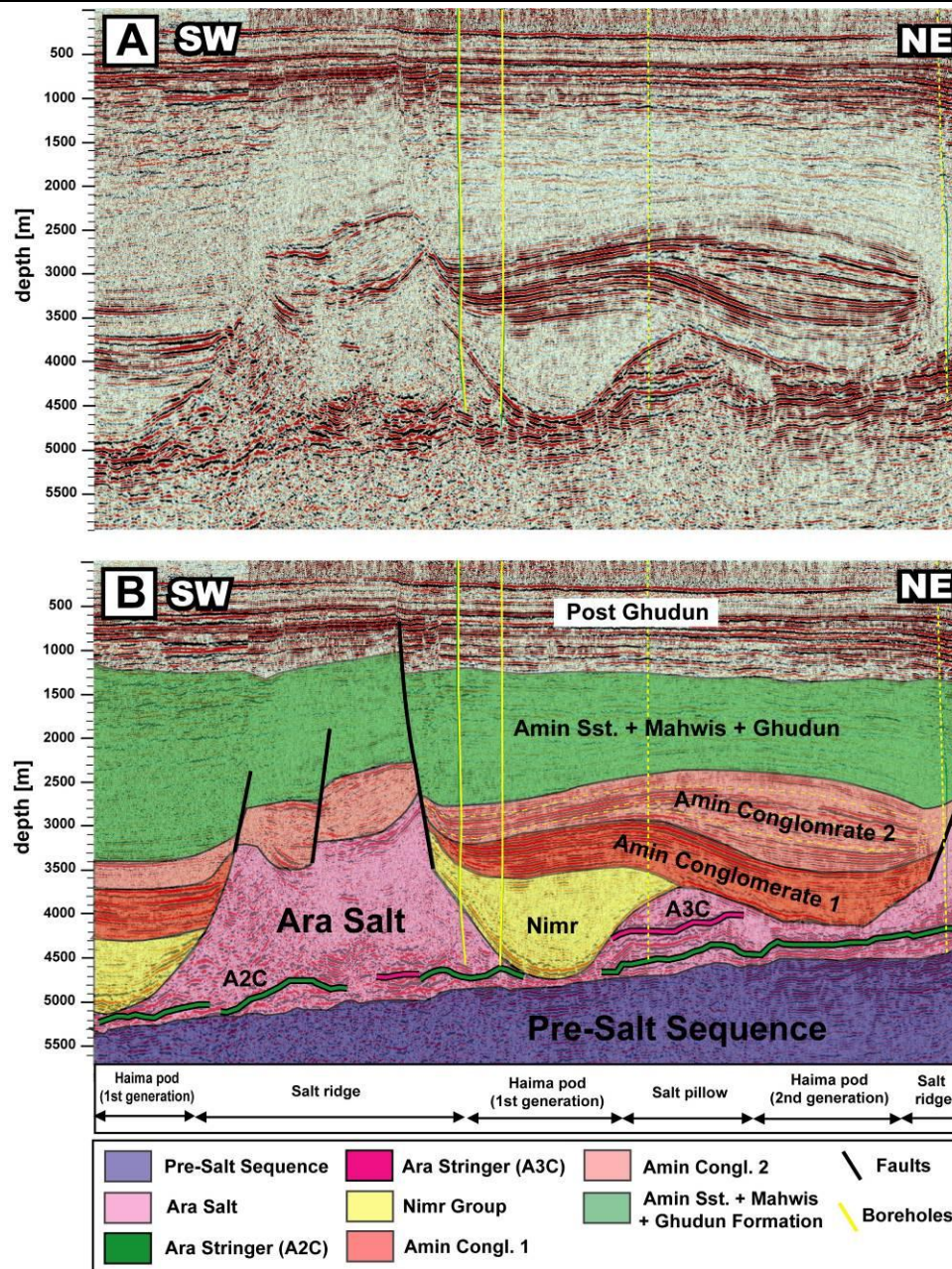
Schoenherr et al. 2007, AAPG Bulletin 92

Depositional Model of the Ara Group

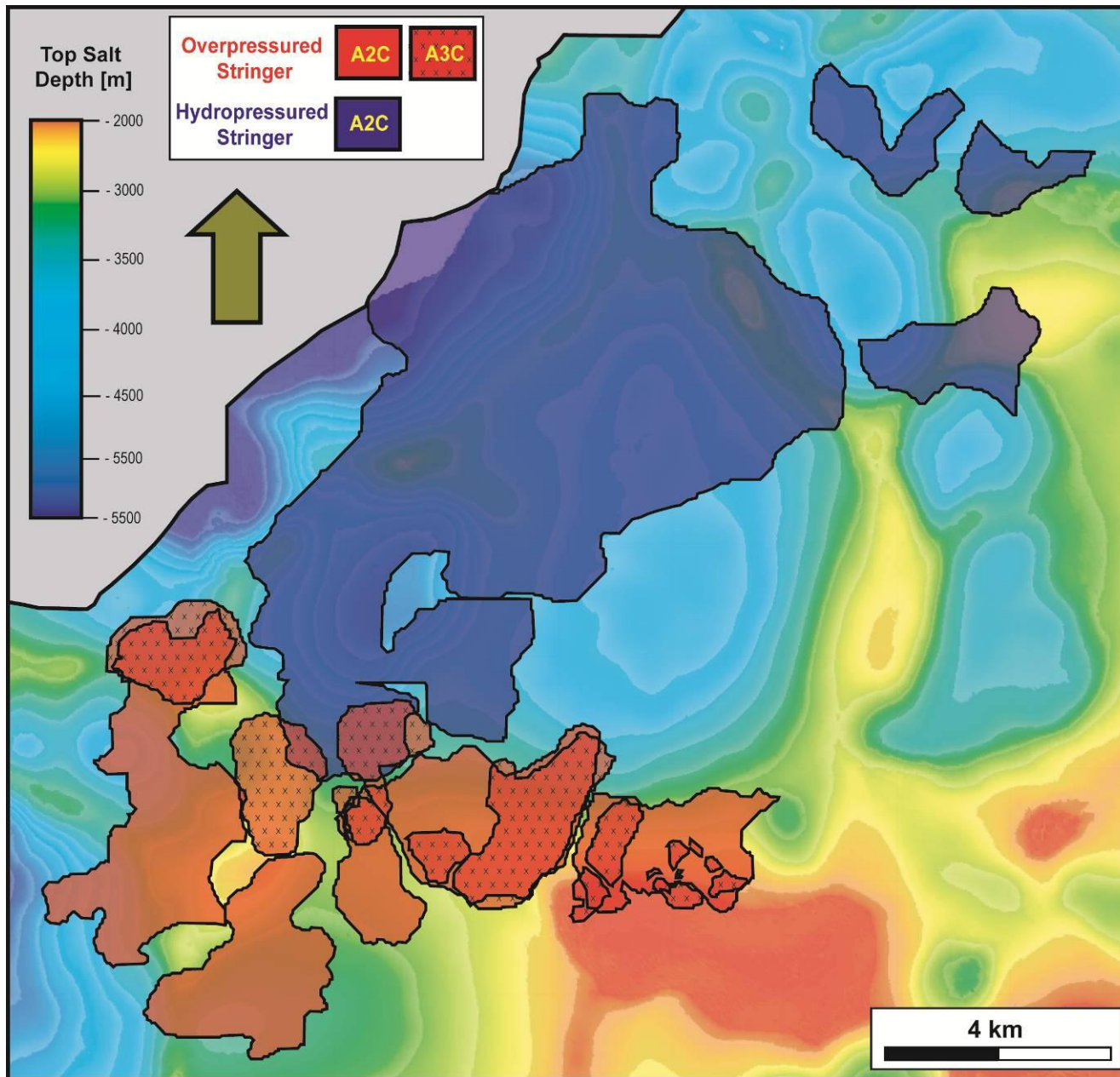


Burial History & Diagenesis

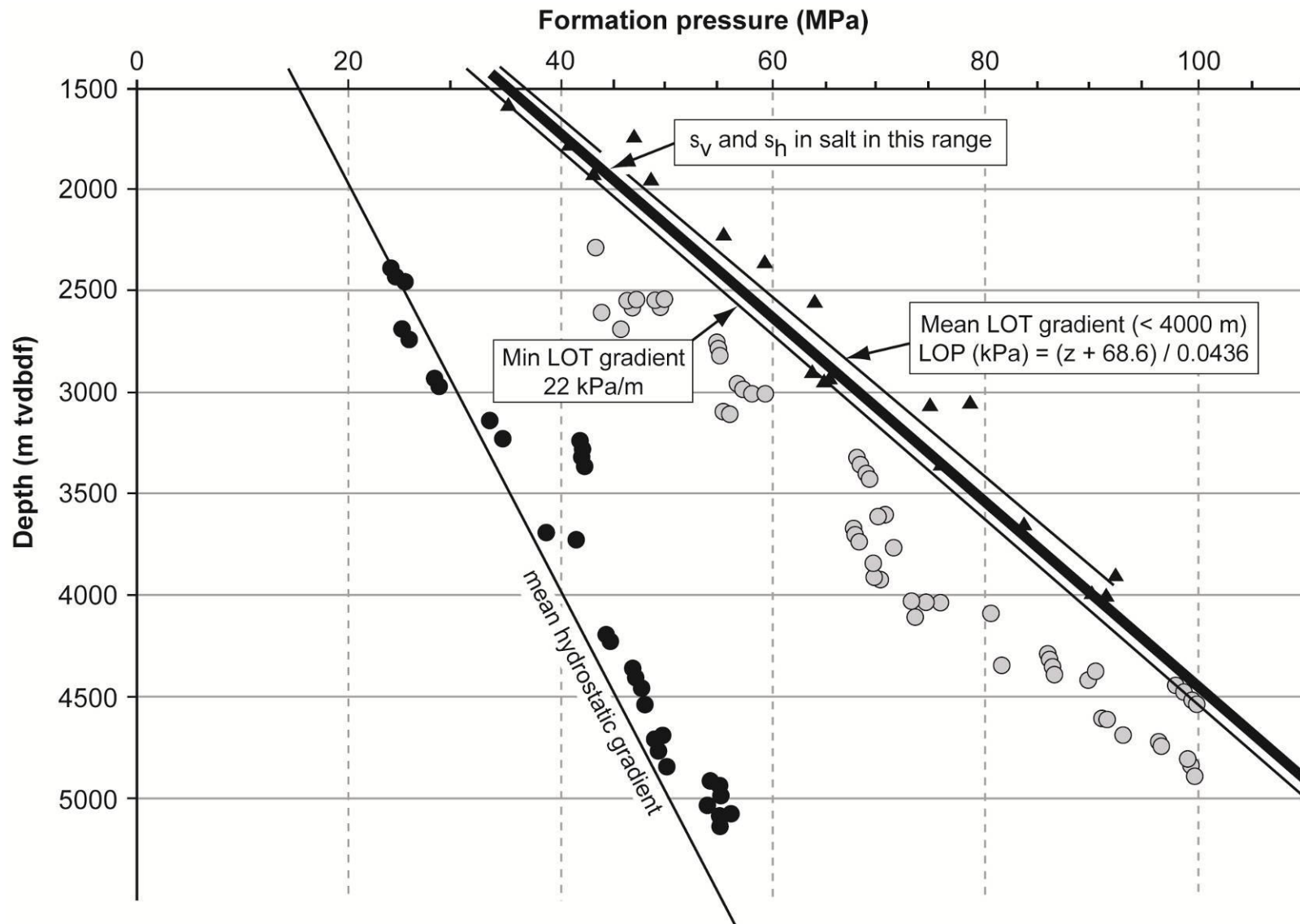




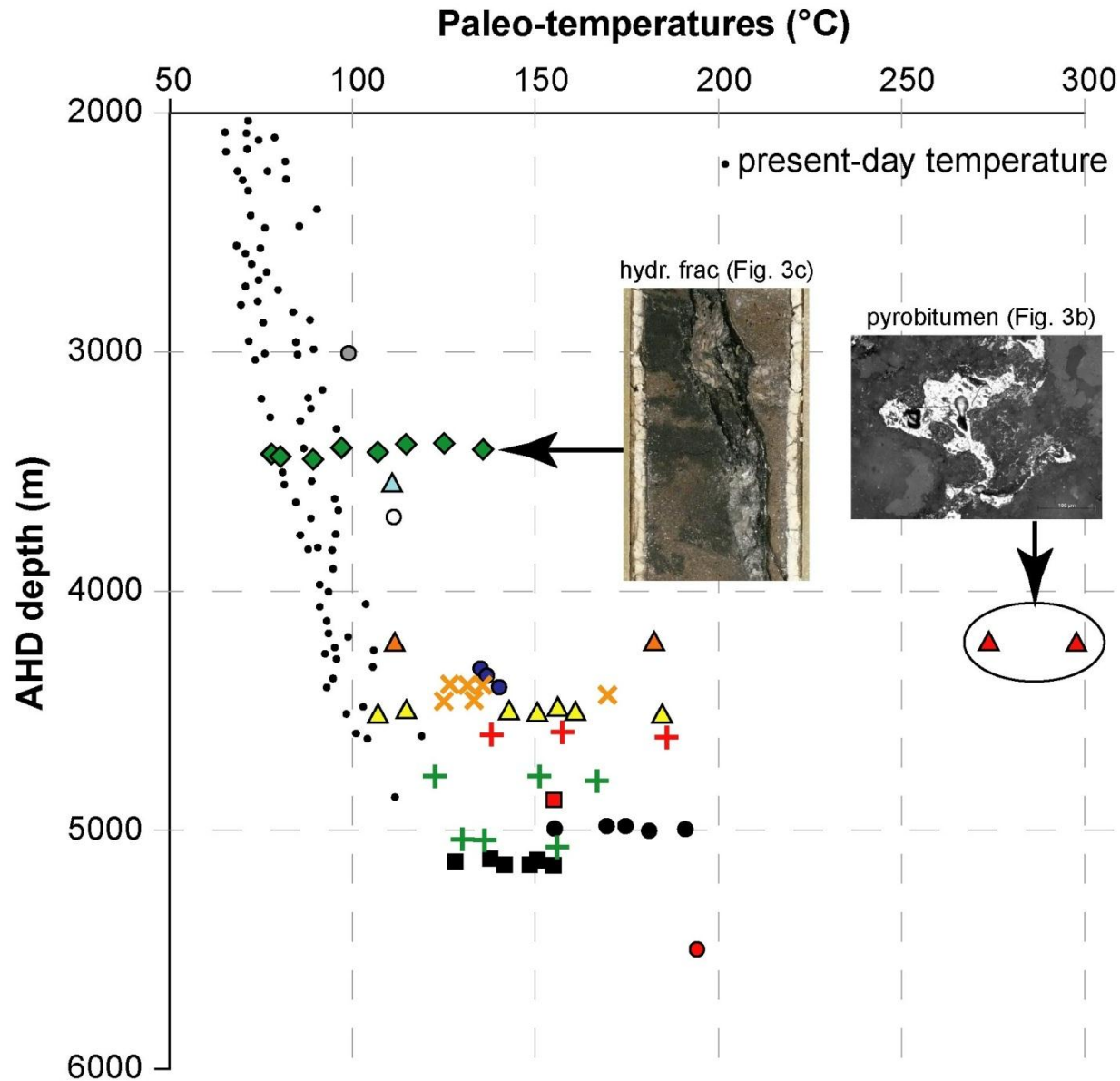
Regional Pressure Cells



Pore pressures and LOPs

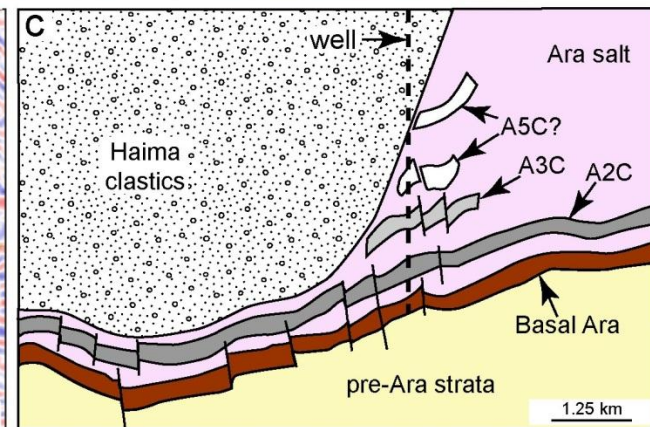
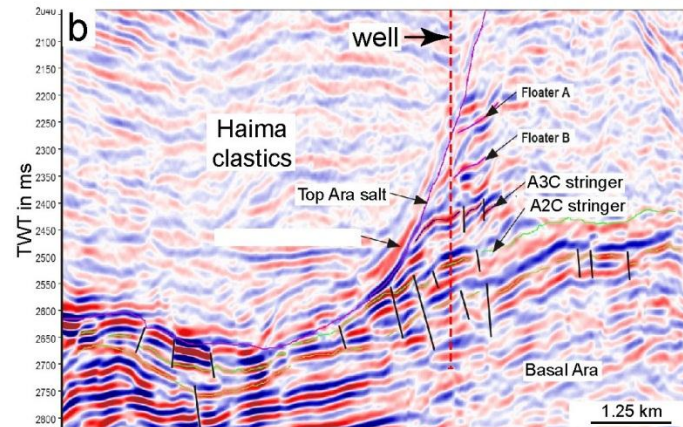
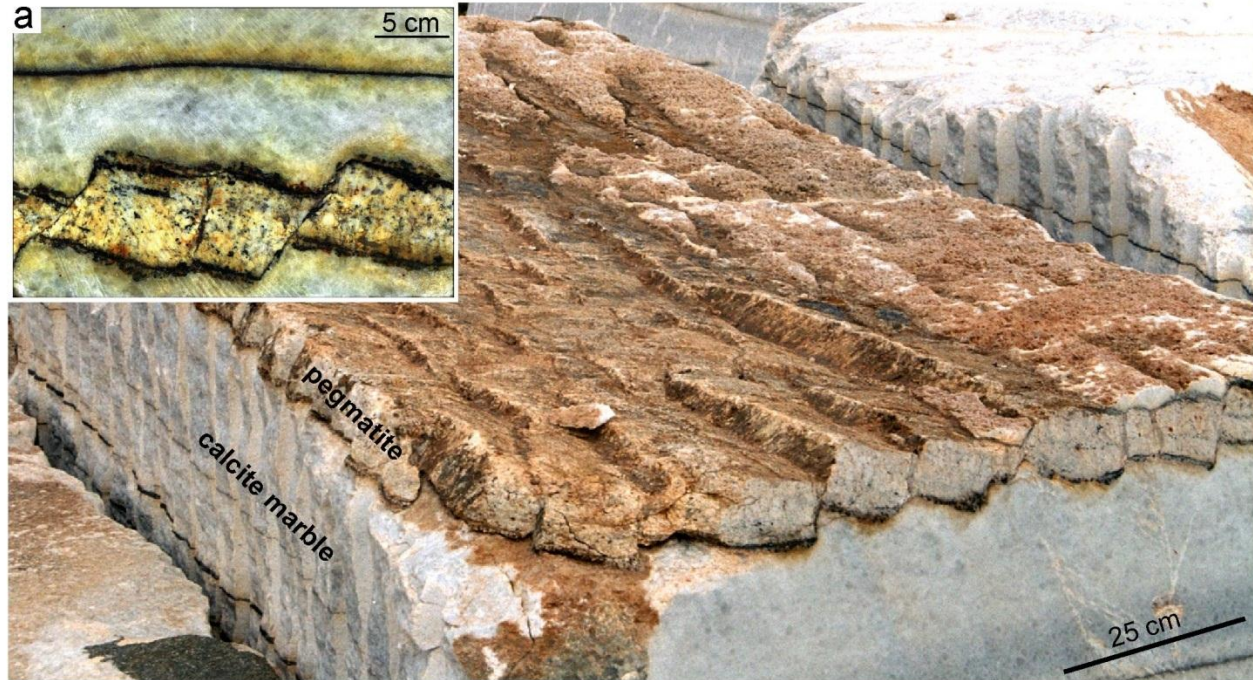


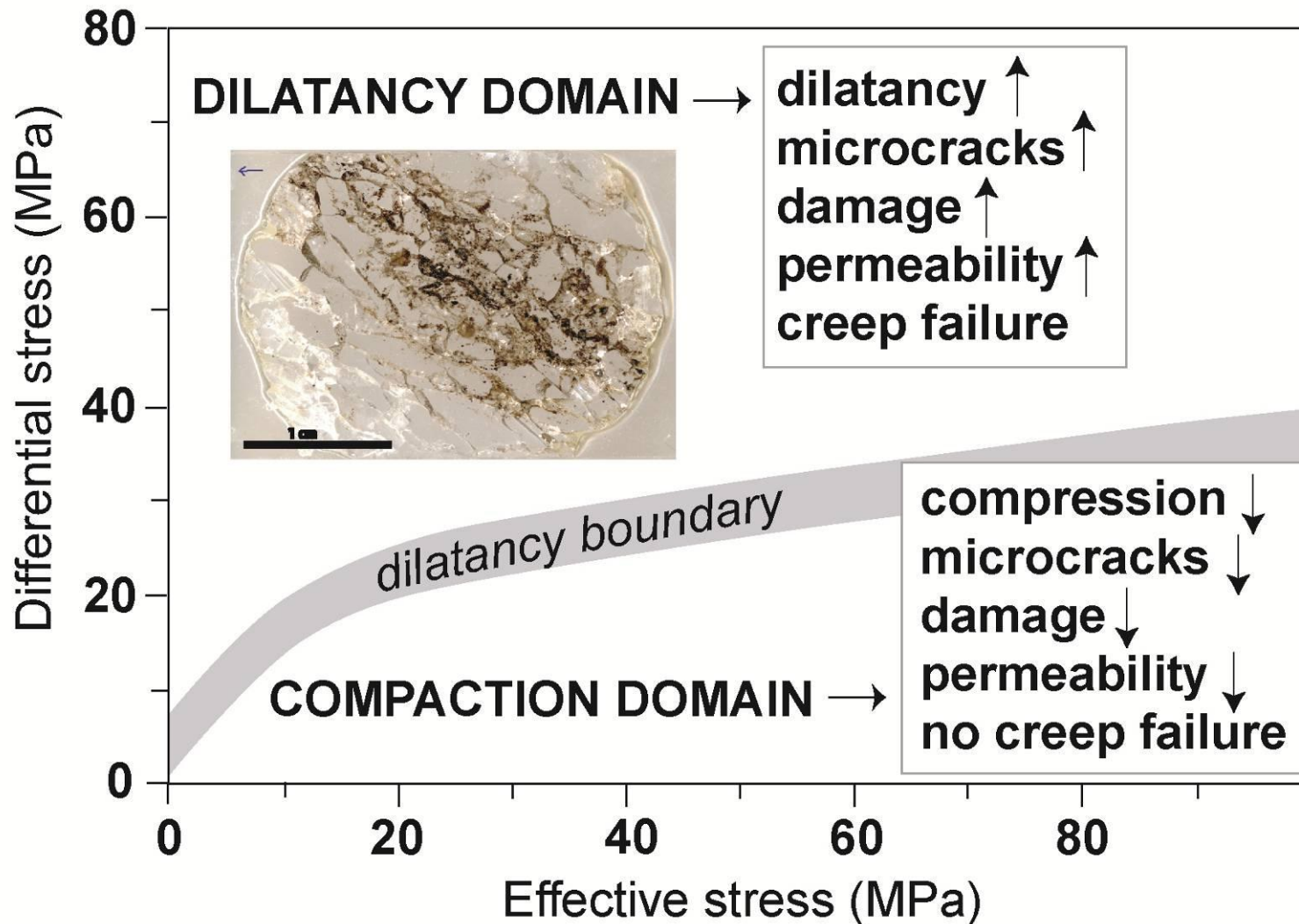
Kukla et al., 2011, Geofluids



Schoenherr et al. 2007, Org. Geochemistry 38

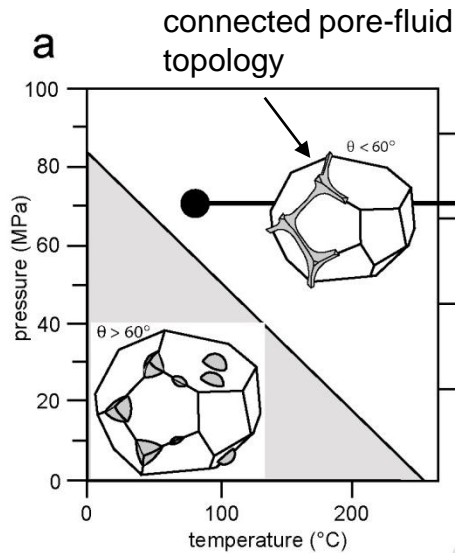
- Boudinaged brittle carbonate/anhydrite rafts moving in salt
- Salt beds considered as pressurized fluid layers overlain by brittle sediment.



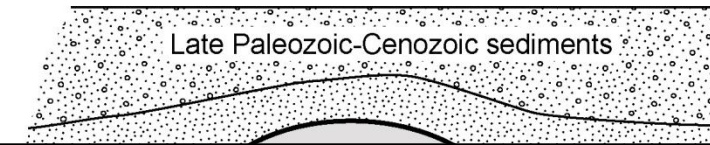


Kukla et al., 2011, Geofluids

Leakage conditions of rock salt in the SOSB



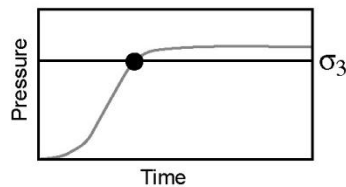
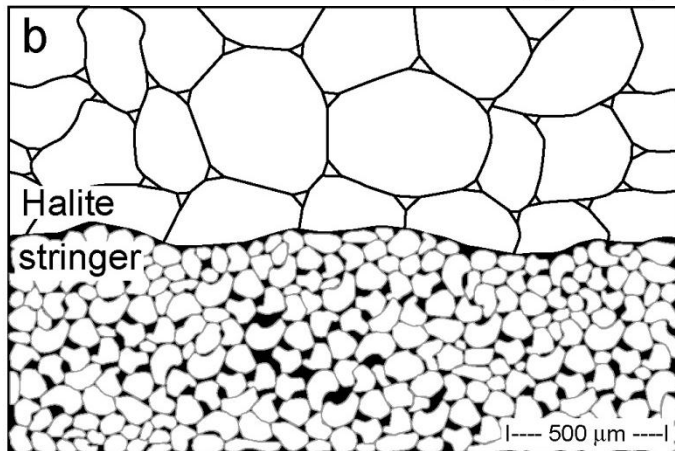
Lewis & Holness, 1996



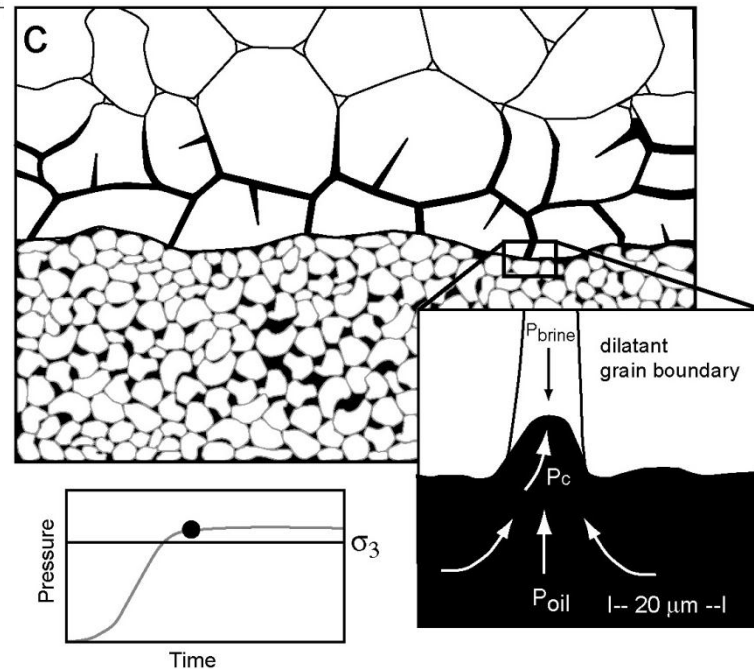
$$P_{\text{brine}} \approx \sigma_3$$

$$P_{\text{oil}} > \sigma_3$$

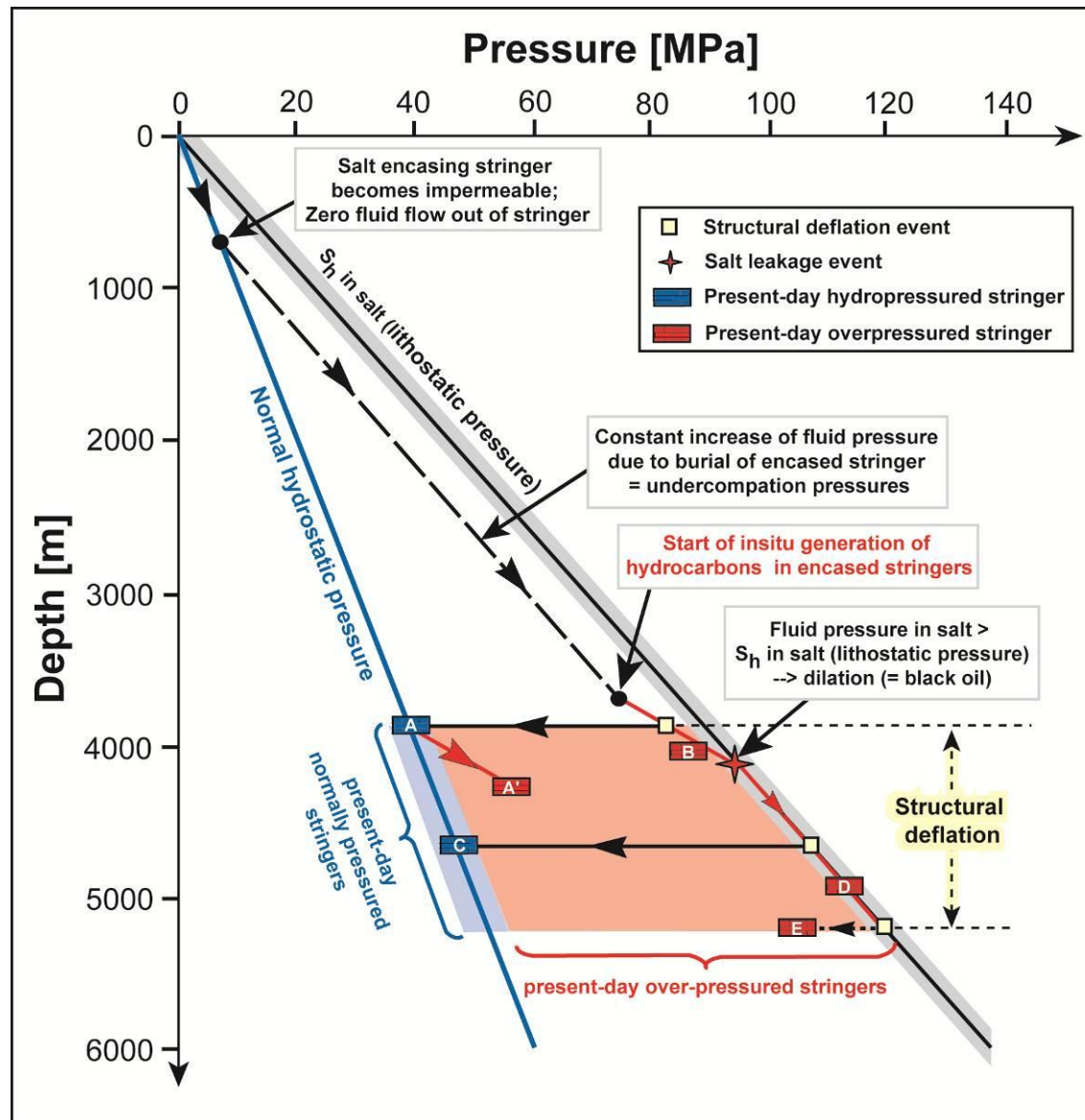
if $P_{\text{oil}} + P_{\text{capillary}} \rightarrow$ Salt dilates!



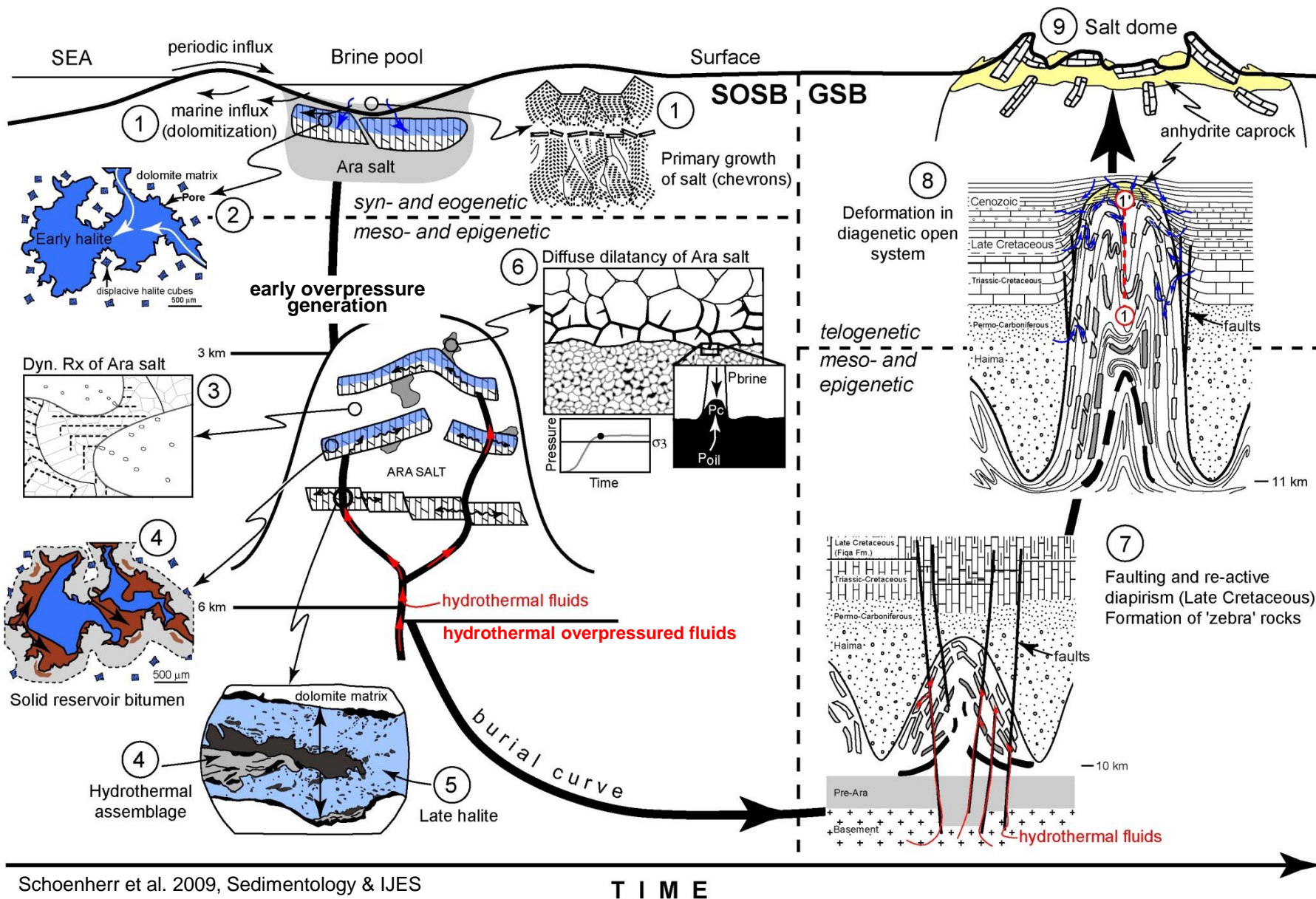
Schoenherr et al. 2007, AAPG Bulletin 92



Fluid Pressure generation and deflation - Summary

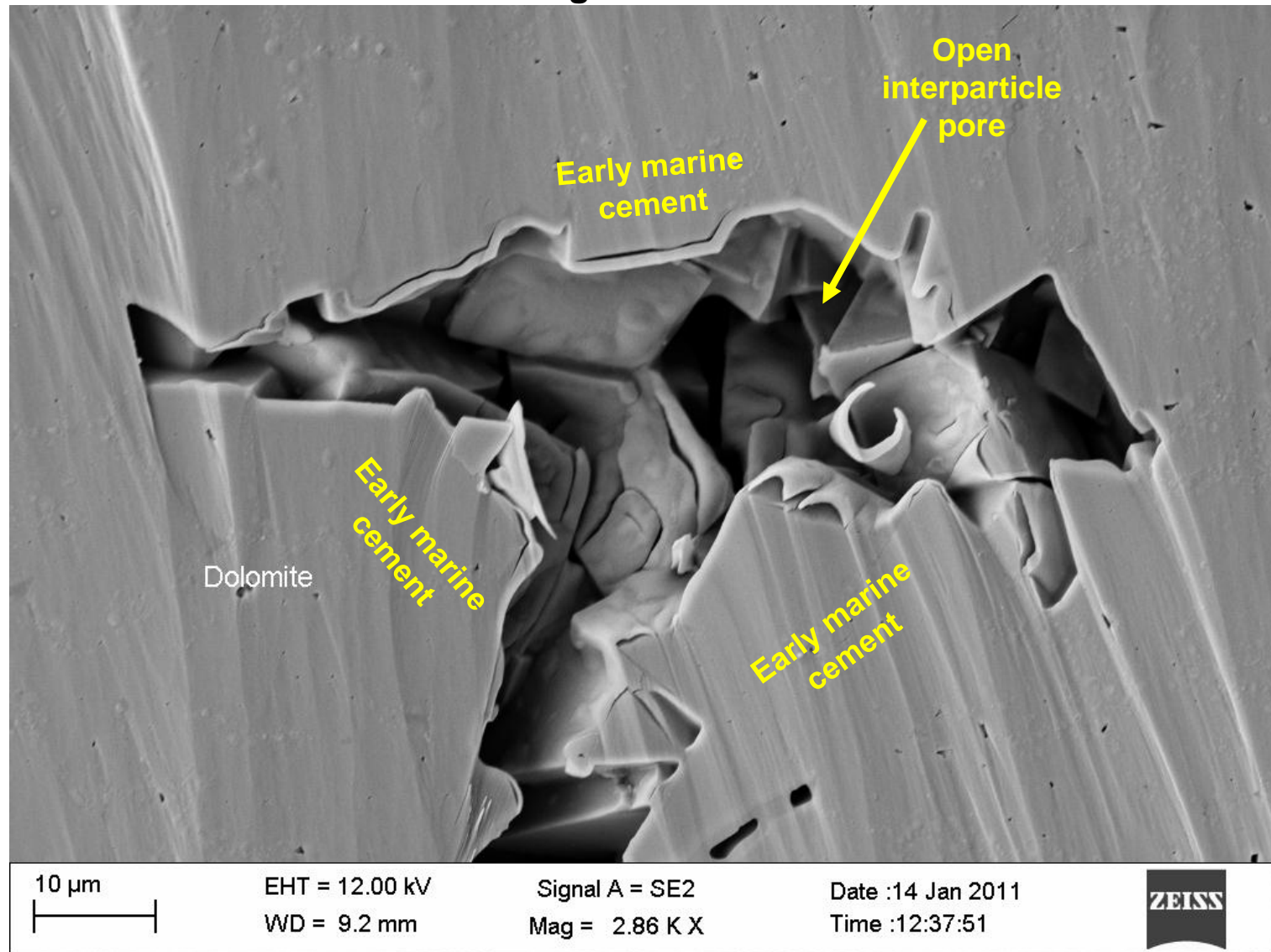


South Oman Salt Basin - Evaporite Basin Model



- The Ara Sequence contains a unique self-charging system, operating since the Cambrian until present day, with respect to overpressure (and hydrocarbon) generation and dissipation.
- Pressure generation and deflation mechanisms are controlled by salt tectonic, microstructural (grain boundary network) and thermo-kinetic (burial and kerogen conversion) constraints and parameters.
- The sequence of events includes initially fast burial and early overpressure generation by disequilibrium compaction, to be followed by thermal fluid effects and kerogen conversion. Pyrobitumen confirms local contribution by a high-temperature hydrothermal event.
- Pressure deflation responsible for presently hydropressured reservoirs is conceivable by structural configurations to adjacent clastic minibasins or by further isolation and fluid injection into surrounding rock salt once minimum principal stress levels have been reached to dilate the salt.
- Impact of pressures on reservoir quality, i.e. late cements, (pyro-) bitumen
- Integrated pressure prediction in such settings needs to consider basin evolution through time with focus on structural settings, geomechanics and geochemical constraints.
- The processes revealed in this study are considered significant for other evaporite basins.

**Interparticle porosity (partially filled with early marine dolomite cement);
carbonate stringer encased in rock salt**



Thank You !

- Petroleum Development Oman LLC (PDO)
- Ministry of Oil and Gas (MOG) Oman
- German University of Technology in Oman (GUtech)
- Halliburton/Landmark for DrillWorks Predict Software
- Badley Ashton Inc., Reslab & Shuram Oil & Gas

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