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Optical Kerogen Analysis

Optical Kerogen Analysis – Methods

geochemical analysis

- widely used in industry for kerogen analysis & HC potential
- based on interpretation of chemical parameters - mainly H- & O-content (RockEval) and biomarker
- **based on bulk rock samples, unable to identify mixed kerogen** (composition, maturation, preservation),
- effect of mixed kerogens on chemical parameters not understood yet
- depending on the kerogen mix chemical parameters can mislead HC interpretation

optical analysis

- often used in academic research (palynology / palynofacies)
- kerogen is isolated from the rock and directly studied under the microscope
- **identifies mixed kerogen** (composition, preservation & maturation)
- **component specific quantification of kerogen composition, preservation & maturation for improved HC potential analysis**
- optical kerogen analysis data can be implemented into organofacies based HC system modeling directly

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Optical Kerogen Analysis is focused on:

Kerogen composition

- composition refers directly to the type of HC's, primary generated from source rocks.
- quantification of different types of organic matter (organofacies) and correlation to kerogen types

Kerogen Preservation

- information on HC generation from Kerogen
- HC generation causes increasing degradation - poor to very poor preservation typical for high potential source rocks

Kerogen Maturation

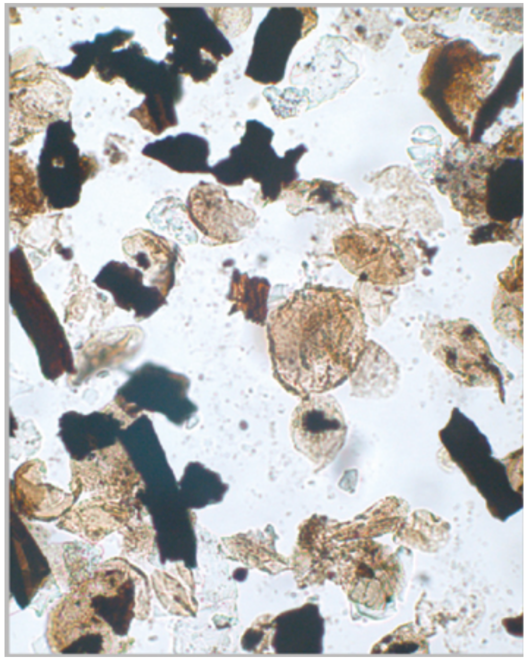
- Information if source rocks are productive or not (immature, overmature)
- Based on vitrinite reflectance analysis & palynomorph colour indices

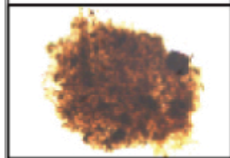
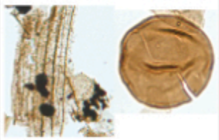
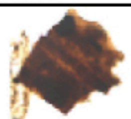
TOC analysis - for analysis of HC-quantity

Optical Kerogen Analysis – Kerogen composition

Identification & quantification of different groups of organic matter in the slide

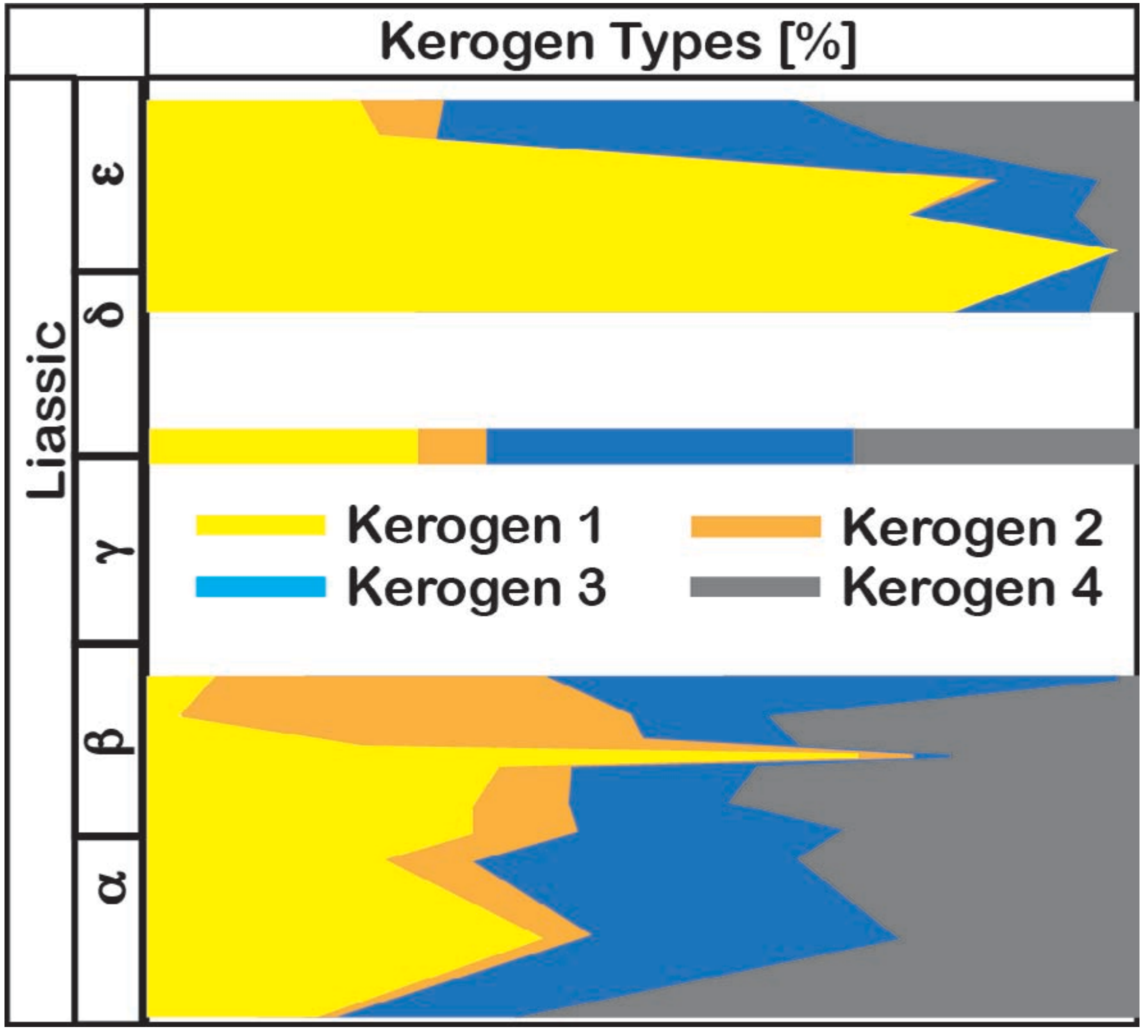
Transfering quantities of palynological groups into HC relevant kerogen types



	Palynological Kerogen Classification	Organic Matter	Hydrocarbon Potential	Kerogen type
	AOM Cutinite	AOM (sensu strictu), algae, bacteria, phytoplankton	Very high oil potential	I
	Cutinite	mainly terrestrial palynomorphs, plant tissues, (phytoplankton)	High oil potential	II
	Vitrinite	mainly woody plant debris (of higher land plants)	Low oil potential High gas potential	III
	Inertinite	highly carbonized opaque, inert organic matter	Very little – no hydrocarbon potential	IV

Optical Kerogen Analysis – Kerogen composition

- Quantification of all kerogen types in each sample
- Quantification of productive vs. unproductive kerogen
- Quantification of oil-prone vs. gas prone kerogen
- Development of detailed kerogen composition within source rock unit

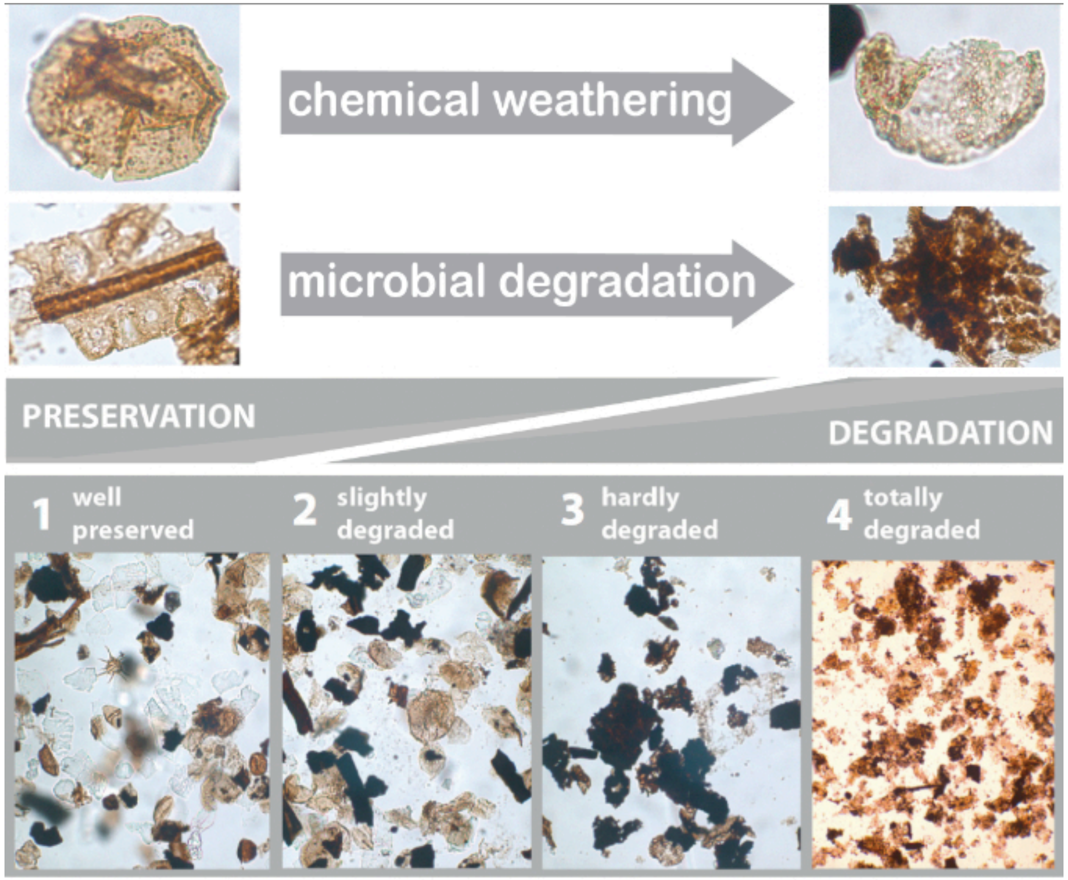


Optical Kerogen Analysis – Kerogen preservation

- primary degradation: microbial & chemical,
- secondary degradation related to maturation
- maturation related degradation indicates level of hydrocarbon generation from actual kerogen

- preservation is directly linked to microporosity in organic matter

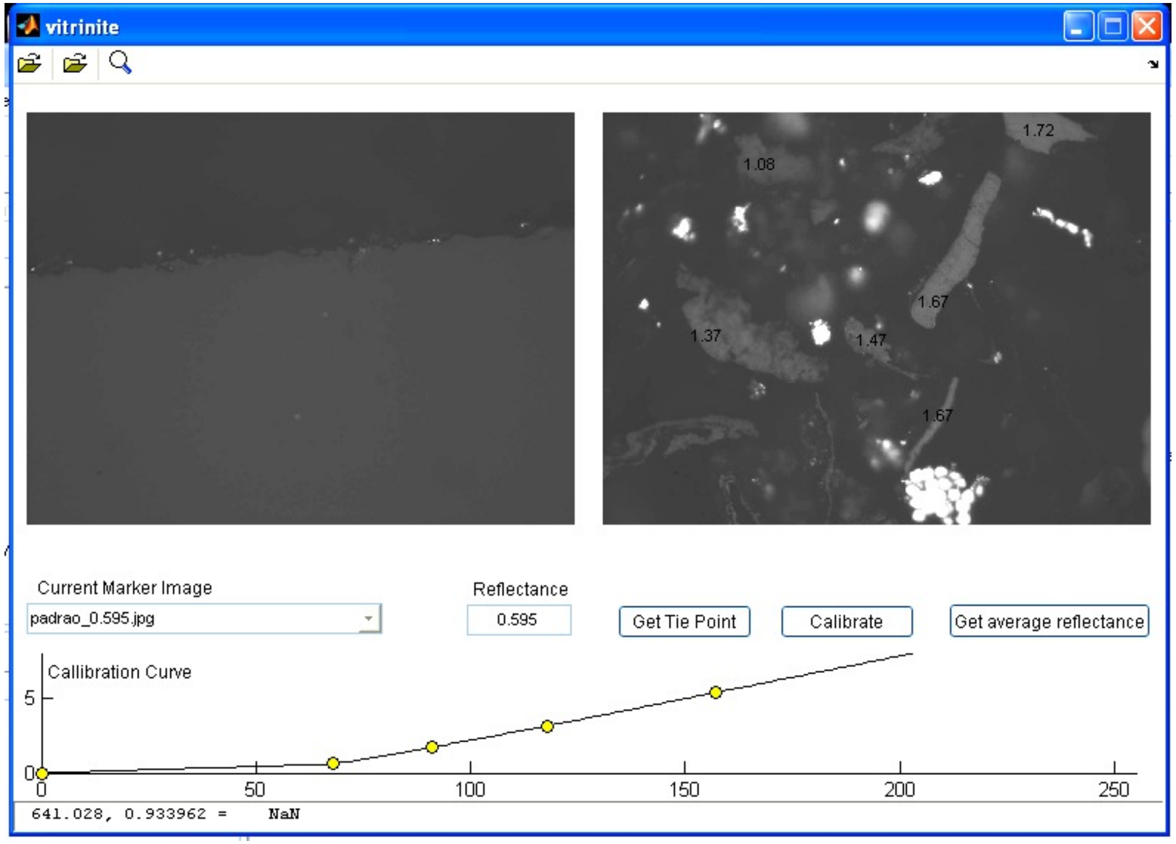
  ≈ storage capacity for shale gas



1 well preserved – no visible degradation of organic matter
2 slightly degraded – slight degradation at surface of organic matter
3 hardly degraded – primary organic particles partially destroyed
4 totally degraded – primary organic particles totally destroyed - AOM

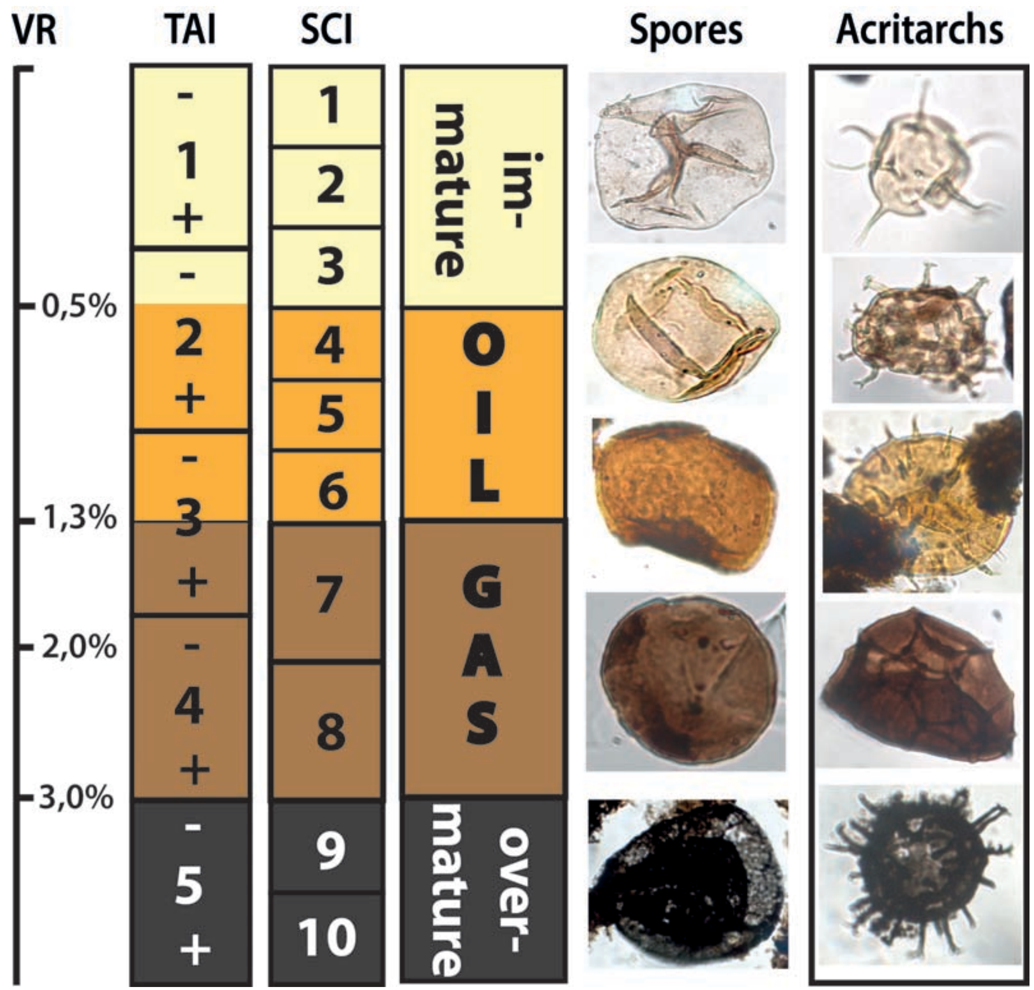
Optical Kerogen Analysis – Kerogen maturation

- high-resolution VR analysis based on digital image analysis
- transfering greyscales into VR data
- precise VR measurements on small vitrinite grains down to pixel-size, depending on image resolution
- optical control of analysed particles (type of kerogen, preservation…)



Optical Kerogen Analysis – Kerogen maturation

- Intgrated maturation analysis VR & color indices
- Palynomorph color indices (TAI, SCI) are additional methods - first estimates of maturation
- Vitrinite availability limited by stratigraphy (post-mid Silurian) and lithology/ facies
- SCI/TAI analysis when vitrinite is not available & for chross-check of VR data
- combination of VR & TAI/SCI for maximum accessibility and reliability of maturation data



Case Study I

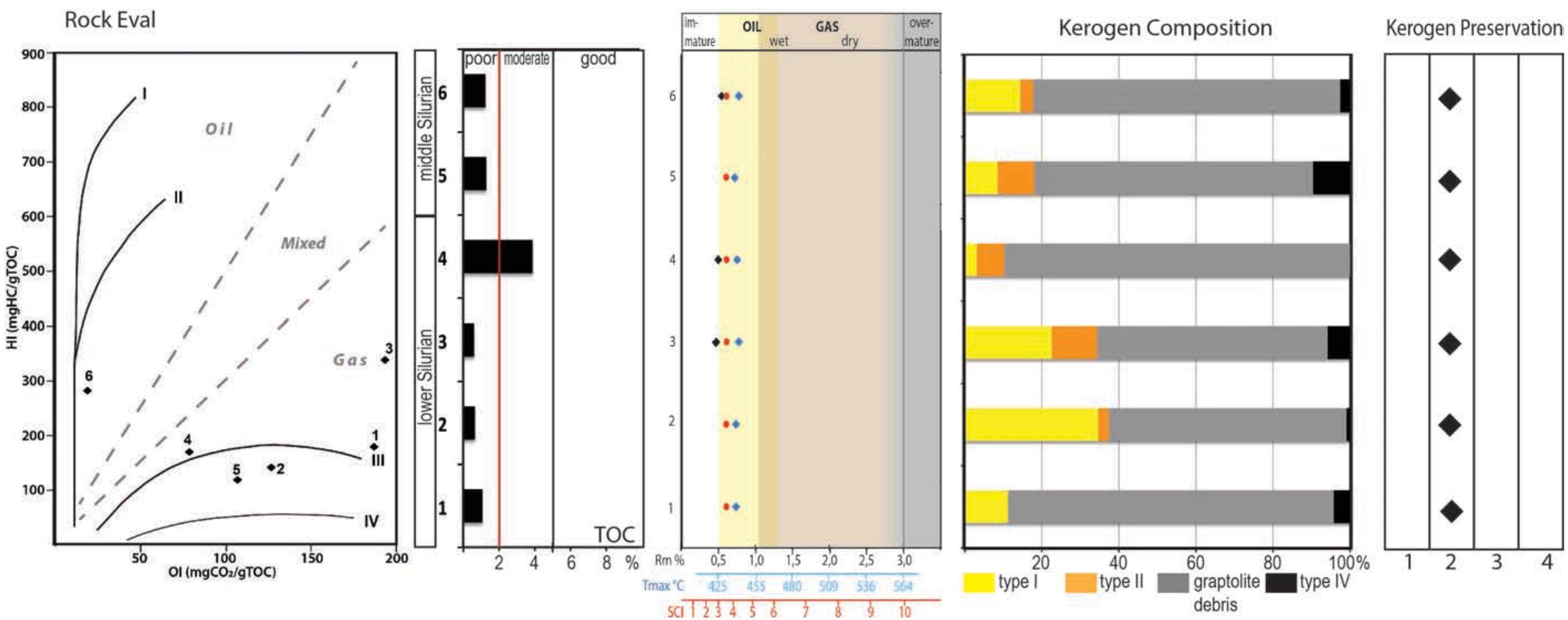
Paleozoic shales in Europe potential unconventional HC-plays

Paleozoic Shales – SE-Poland

- southern Holy Cross Mts.
- Lower – Middle Silurian
- Dark/black organic rich shales, partially limestone nodules, rich in graptolites
- Total thickness: 15m (Llandovery)
  45m Wenlock
- TOC (old): 1-2,5% (residual, 2-5% initial)
- Maturity (old): *VR > 1,3%*

Silurian black shales – SE Poland

Paleozoic Shales – SE-Poland



TOC mostly poor (<2%)

Kerogen varies, mainly type III

Tmax – 440, middle oil window

'VR' – 0,5% (base oil window),
SCI 3-4 lower oil window

Kerogen I, II & IV, mainly graptolite remains,
no type III - graptolite HC potential

Preservation moderate, no HC generation yet

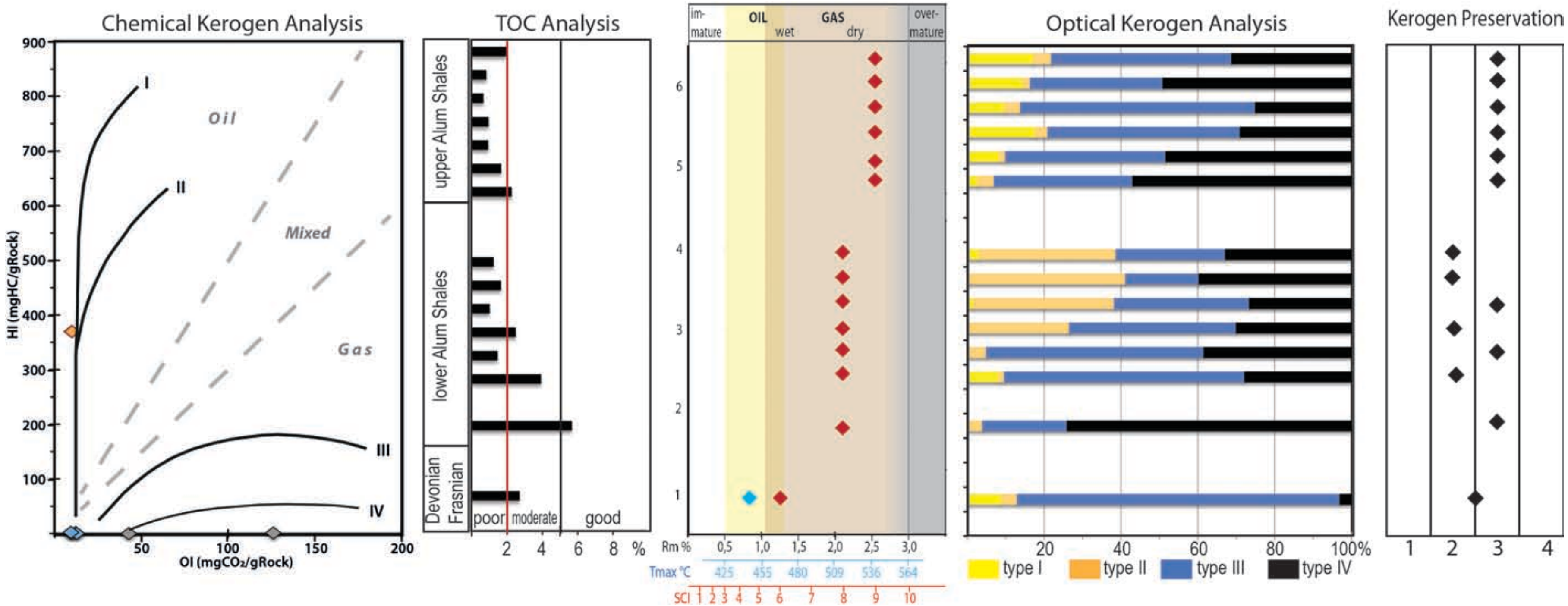
Paleozoic Shales – North German Basin

- SW North German Basin
- Upper Devonian – Frasnian black shales,
- Lower Carboniferous - lower alum shales (Tournaisian) & upper alum shales (Namurian)
- Dark/black shales, partially marlstones & limestone interlayers, rich in C org & pyrite
- Total thickness: 25m (>100m Basin) UAS
  2-5m (50m basin) LAS
  30-50m Devonian FBS
- TOC (old): 2,5-8% LAS, 0,8-2,5% UAS
- Maturity (old): VR = 2,5-3%


Upper Alum Shales – N-Germany


Lower Alum Shales – N-Germany

Paleozoic Shales – North German Basin



TOC poor to moderate

Devonian kerogen I/II

Carboniferous kerogen III/IV

Devonian Tmax – 440 (oil window)

Devonian FBS: kerogen III dominated

Carboniferous: kerogen II/III (LAS)
kerogen I/III (UAS)

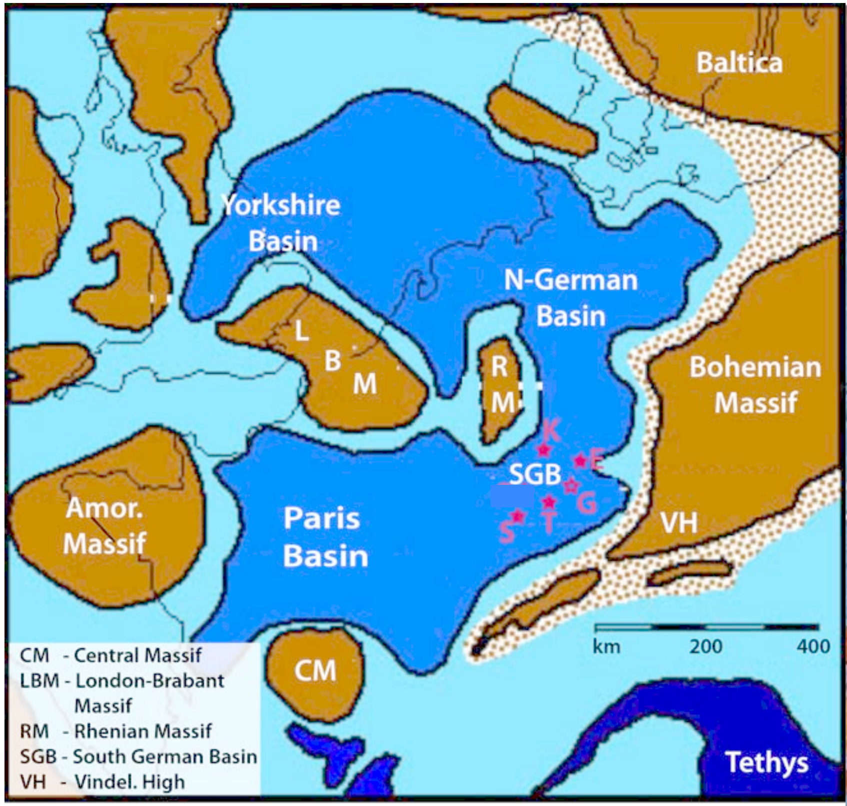
Maturation mainly in gas window

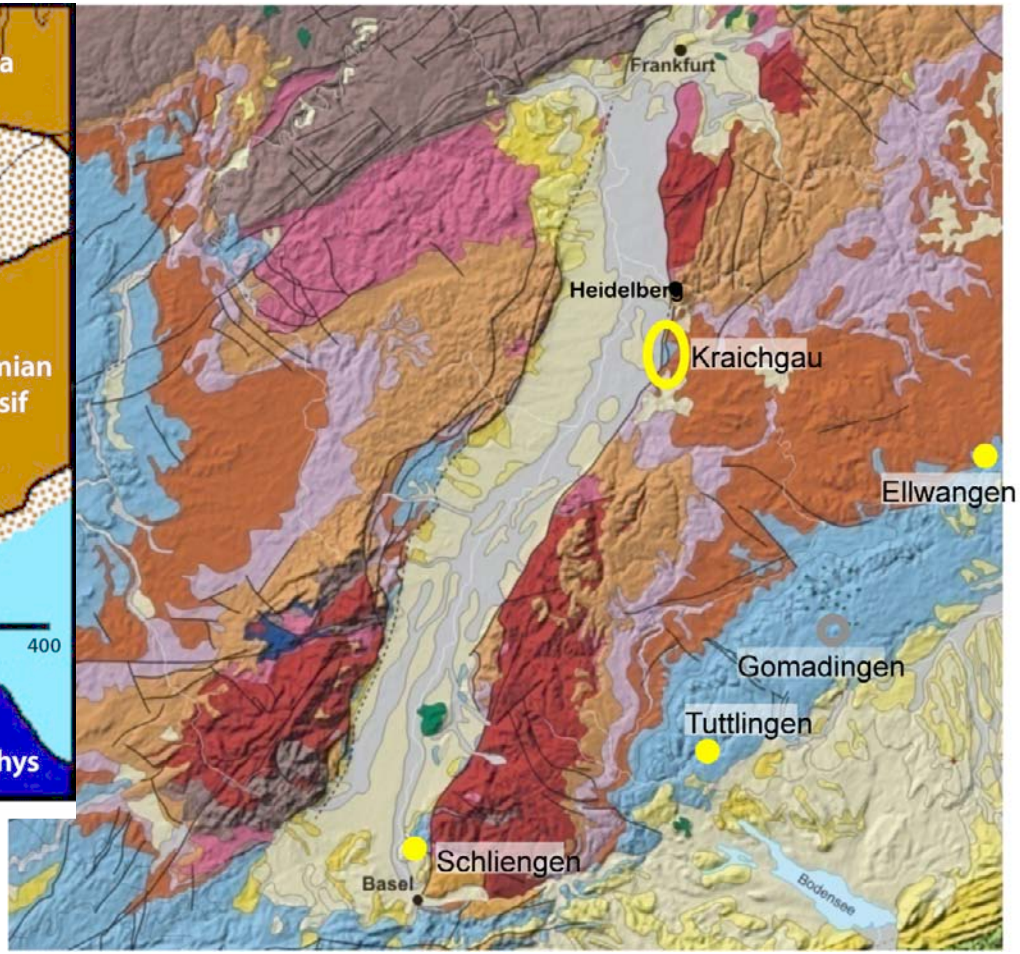
Preservation: slightly to hardly degraded

Case Study II

Lower Jurassic of Southern Germany

Lower Jurassic – S-Germany



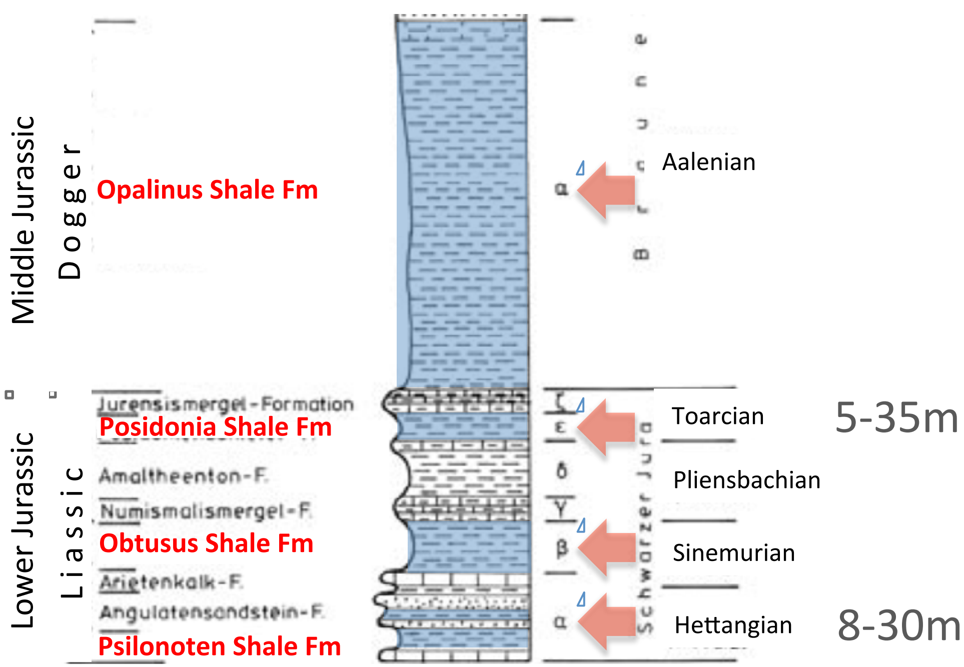


Southern Germany is widely covered by the epi-continental shelf system - basinal to shallow shelf seas

temporarily strongly euxinic conditions (from the basin centers to marginal areas)
all studied wells are placed in area, which is assumed to be (euxinic) - central basin facies

Lower Jurassic – S-Germany

Potential source rock units



All studied intervals are mainly made of dark to black, marl- to mudstones, rich in pyrite

varying proportions of limestones in different shale intervals (e.g. Lias α / Lias ε), but also within one unit in different localities

partially highly frequent changes between euxinic and oxic conditions (bioturbation)

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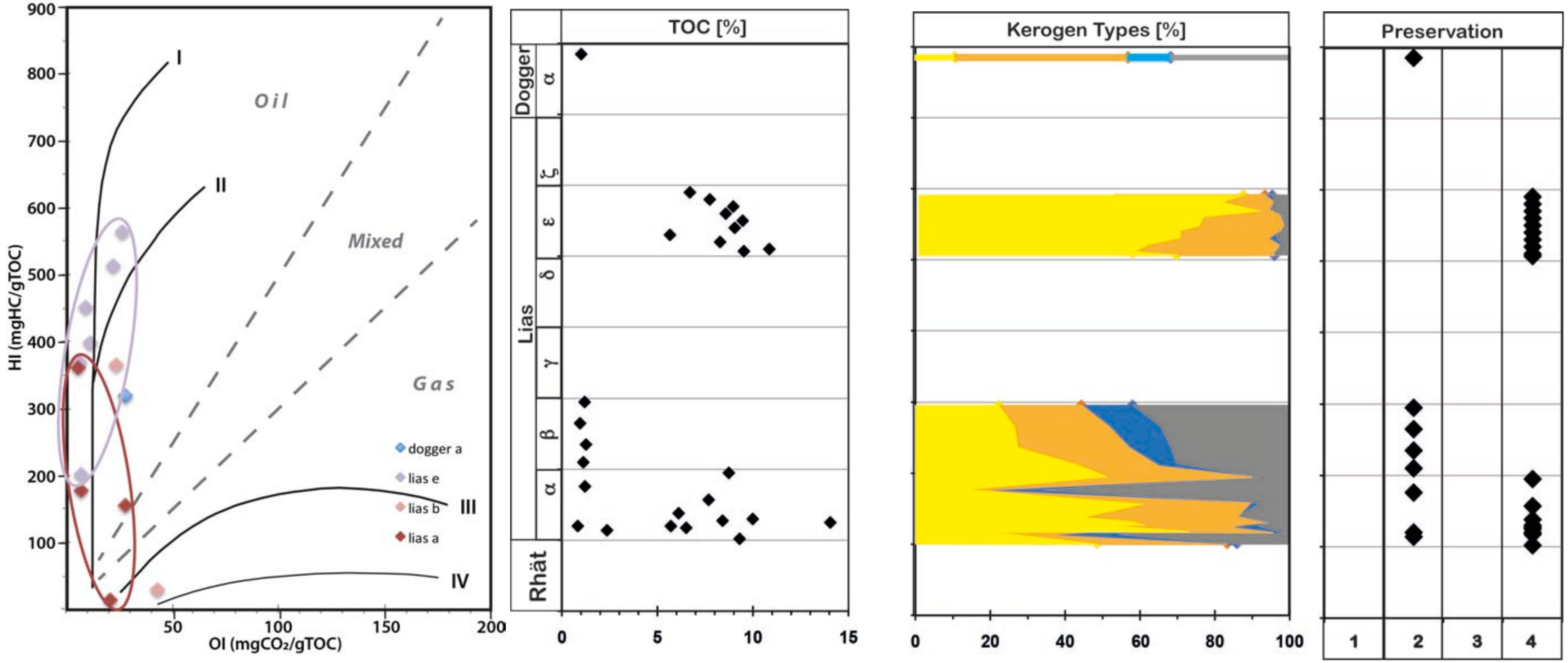
Lower Jurassic – S-Germany



High TOC: 5-12% (≤ 2% Lias a)

Lias e: kerogen I (– II)

Lias a: kerogen II (– III)

Maturation: middle oil window (SCI)

Lias e: dominated by kerogen I, minor kerogen II (IV)

Lias a: high amounts of kerogen I & II, minor kerogen IV, no kerogen III

Lias a/e: poor preservation, high HC generation

Optical Kerogen Analysis - Benefits

- detailed quantification of each single kerogen type within the total kerogen
- quantification of productive vs. unproductive proportions of the total kerogen
- quantification of oil-prone vs. gas-prone kerogen within the productive kerogen
- detailed analysis of preservation of each kerogen type - estimation of HC generation from oil-prone and gas-prone parts of kerogen
- high-resolution analysis of organic maturation by two independent methods
- detailed palaeothermal history and HC maturity
- identification of different kerogens with different HC potential mixed within the total kerogen