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Organic Maturation studies

Organic Maturation - Basics

- Change of organic matter in coals and sedimentary rocks due to increasing temperatures

  increase of Carbon

  decrease of light components (H, O, S, N)

  increasing order of aromatic clusters

- Changes lead to changes of geochemical and optical properties

- **Geochemical identification** from *Tmax* (*Rock Eval*) or *biomarker distribution* –
  but - all analysis from *bulk rock* samples - *no identification of mixed kerogen*
  data represent mixed signal from mix of different parts of the kerogen

- **Optical identification** by changing optical properties

  transparency/colour – *darkening of organic matter*
  reflectance – *increasing reflectance of light*
  fluorescence – *decrease of fluorescence intensity / colour*

Two methods of optical analysis – **Palynomorph Color Indices**
Vitrinite Reflectance analysis

Optical analysis – Colour Indices

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Numerical scale based on palynomorph colours

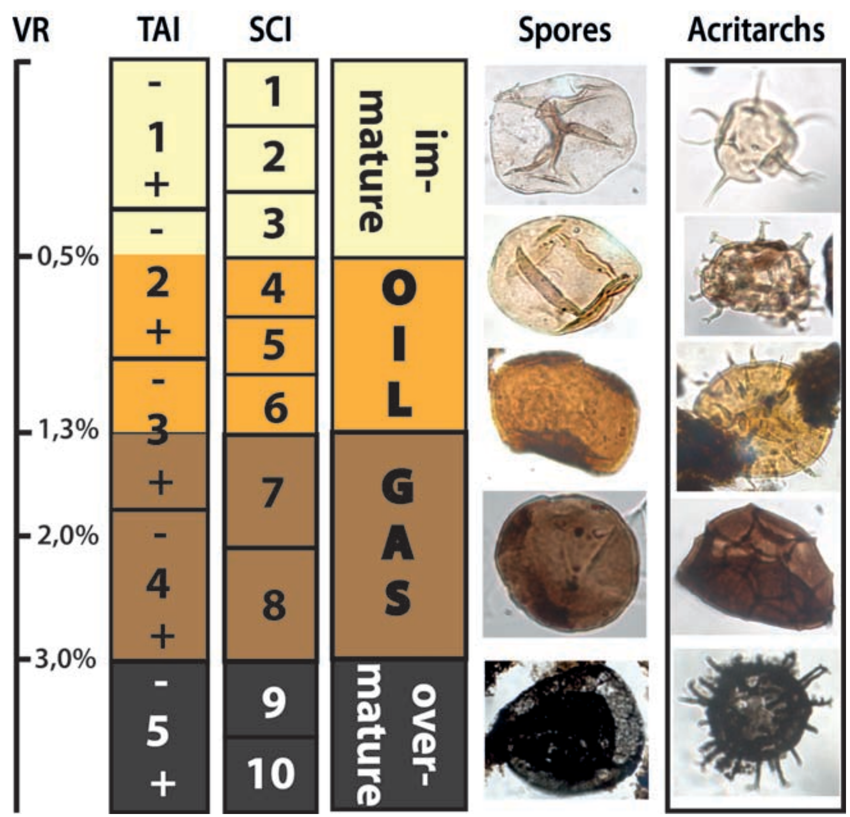
Palynomorph colours darken from translucent/ very light yellow to orange, brown to black

10-point scale from SCI = 1 (translucent / very light yellow) to SCI =10 (black)

Initial assessment of maturation levels, geothermal history and petroleum potential

Pro: fast approach of general maturation levels
identification of recycled, altered or caved organic matter

Contra: subjective colour analysis
maturation analysis based on 10 (5) levels
good estimates of HC generation levels
rough estimates of paleotemperatures



Optical Analysis - Vitrinite reflectance

Vitrinite - one of the three maceral groups recognized and is the major constituent of coals. (The vitrinite group, the inertinite group and the exinite-liptinite group)

cell-wall material / woody tissue of land plants.
absent in pre-Silurian rocks (no land plants)
common in organic-roch sedimentary rocks, and coals

Vitrinite Reflectance

Analysis of vitrinite is made with reflected light microscope using a lens on polished surfaces

Accurate measurements are achieved with the calibration of the r microscope with, at least, two standards of known reflectance.

Pro: precise & standarised technical measurements,
re-calculation of palaeotemperatures
well established correlation with hydrocarbon generation

Contra: identification of recycled ‚old' vitrinite problematic
degradation of vitrinite leads to decrease in reflectance

Vitrinite reflectance – Photometer Analysis

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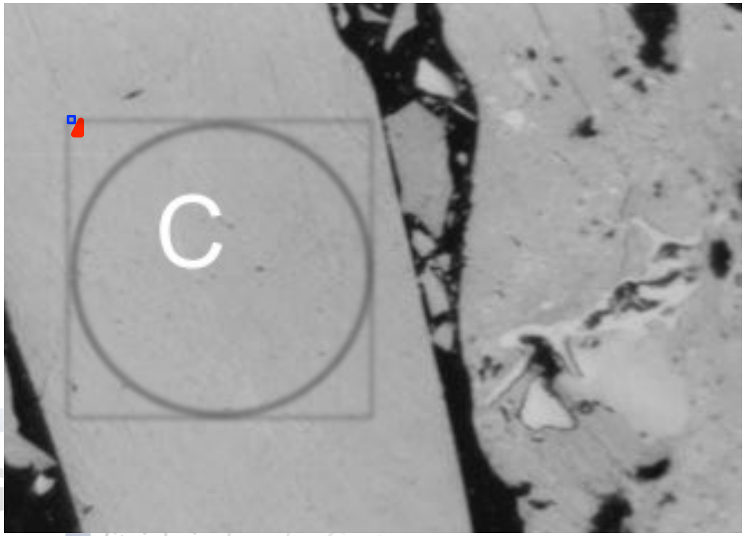
classical standard method used in many labs worldwide today

Reflectance measured in a defined area of the sample, depending on the diameter of the aperture (≥ 100 µm)

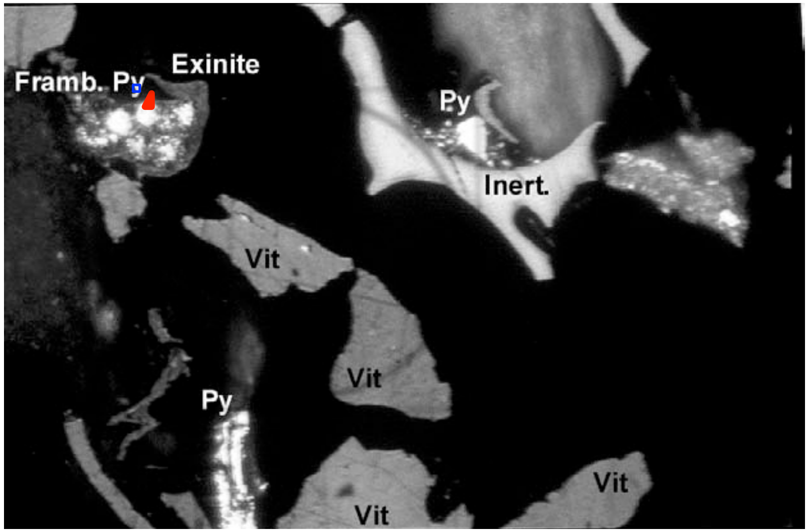
good results for large-sized particles (coal petrography)

mixed signal for small-sized particles (dispersed kerogen) – data correction needed

coal fragments



dispersed kerogen



Vitrinite reflectance – Digital image Analysis

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New method -

based on digital images of calibration standards (left) & organic matter (right) at same conditions at reflected-light microscope

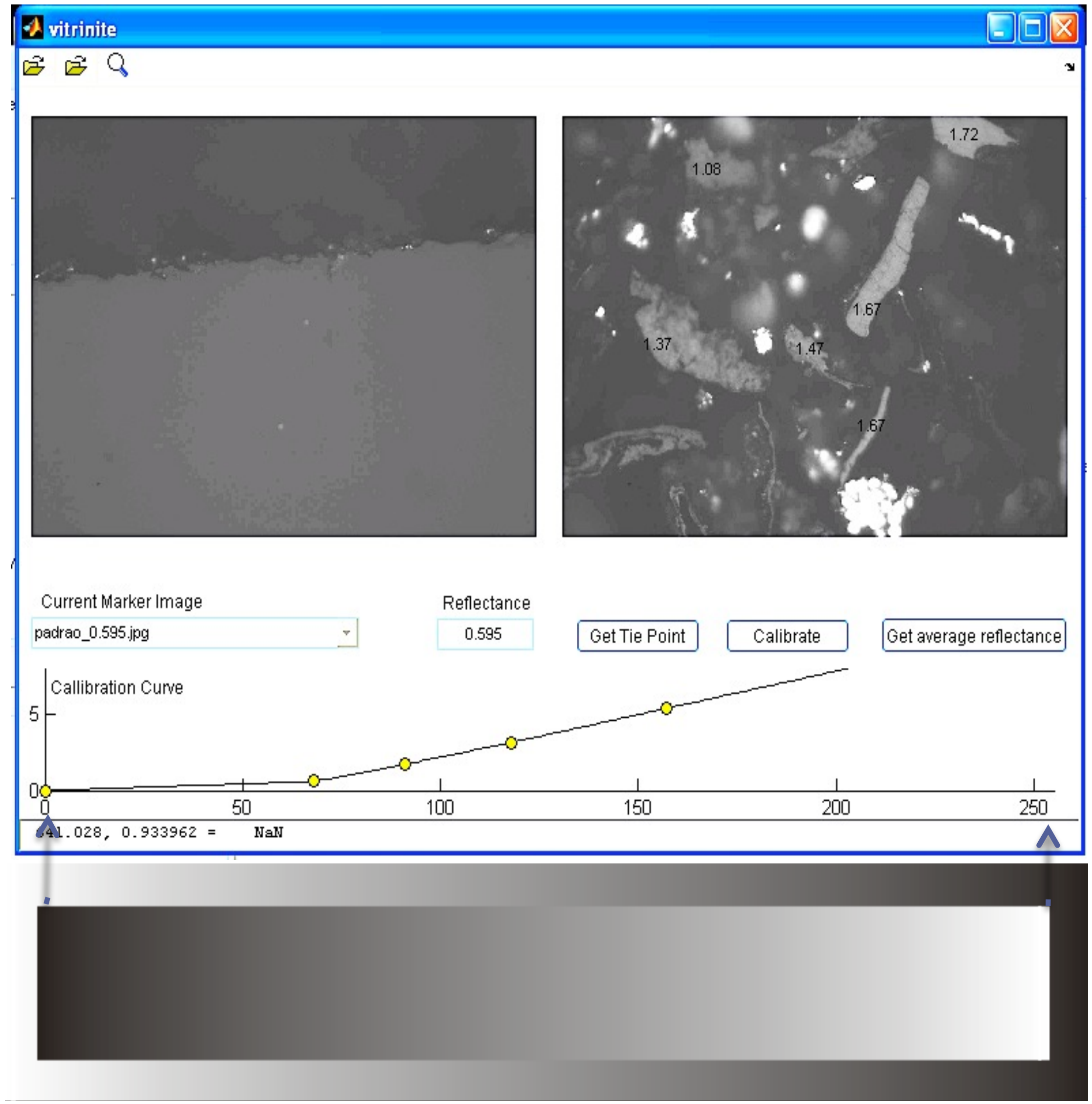
b/w images with 256 grey levels

transforming grey levels of digital images into VR data (%R)

Benefits -

point measurements depending on image resolution (pixel-size)

optical control of analyzed particles (OM-type, preservation…)



Digital image based VR - reliability

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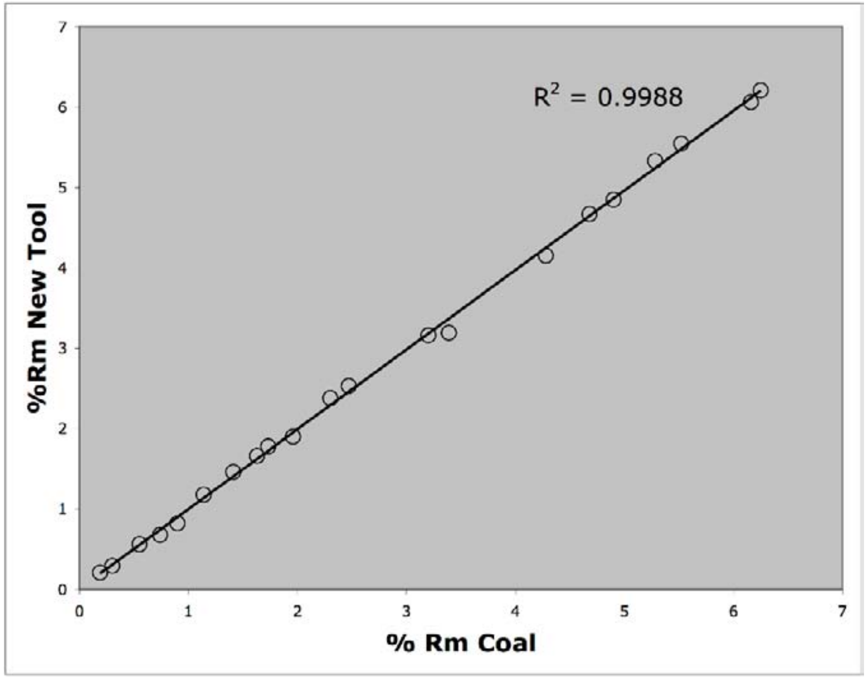
VR correlations using coal samples

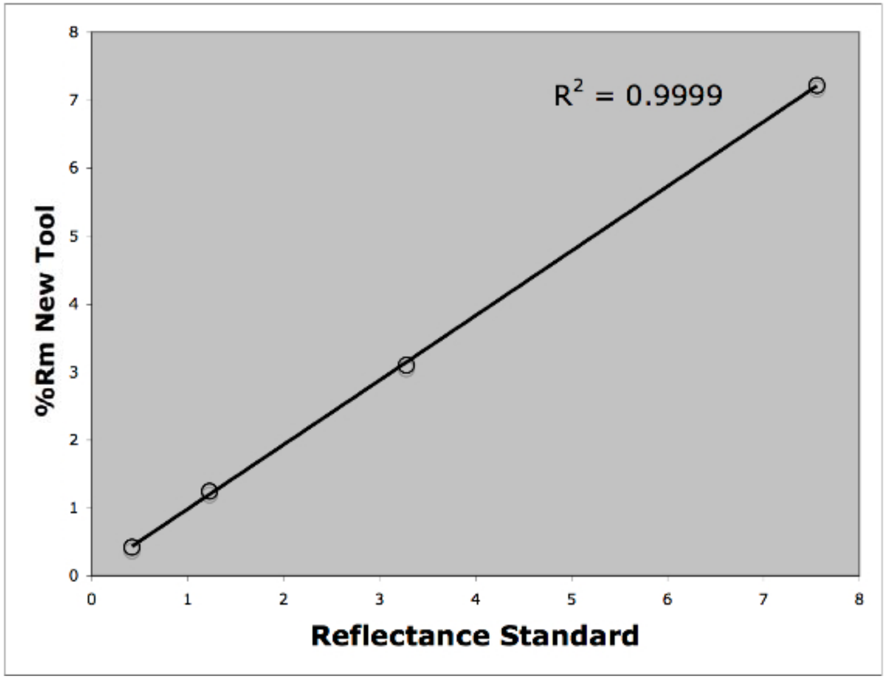


digital image based VR analysis vs. classic photometer VR analysis

21 coal samples measured

from lignite to meta-anthracite (0.19-6.25%Rm)

VR correlations using reflectance standards



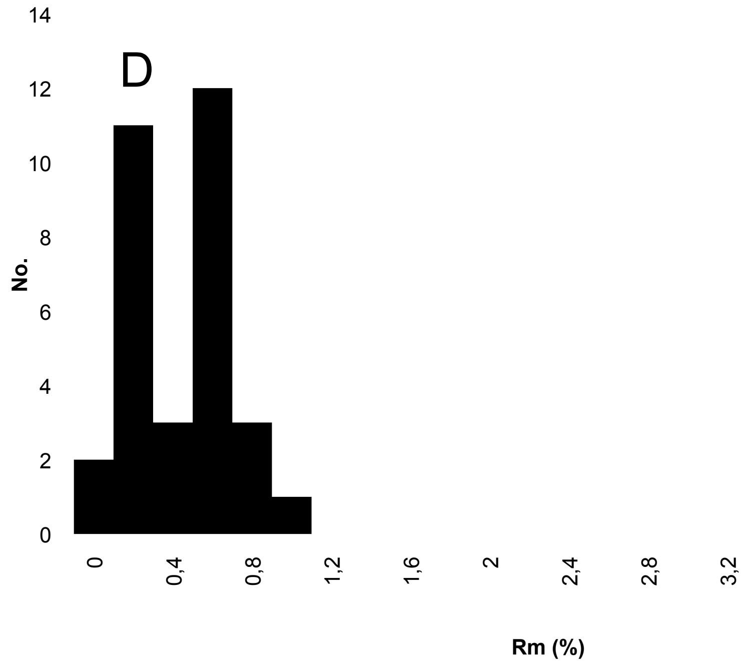
digital image based VR analysis vs. reflectance standards

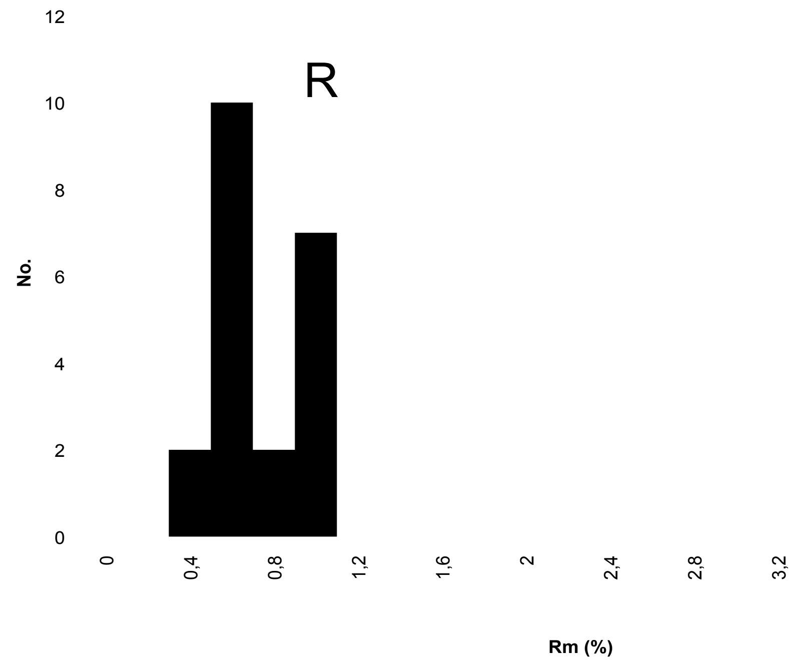
Reflectance Standards: 0.42 / 1.23 / 3.28 / 7.5

Digital VR analysis: 0.42 / 1.24 / 3.1 / 7.22

Digital image based VR – data analysis

Data interpretation of mixed kerogen samples





mixed VR assemblages identified by two (or more) maxima in statistical analysis

identification of different vitrinite populations in digital images – mostly degraded or recycled vitrinite

working with cuttings - caved material as additional source for mixing

Digital image based VR – case studies

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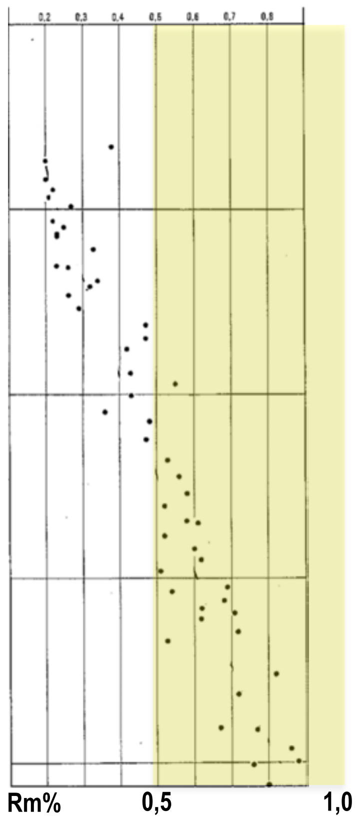
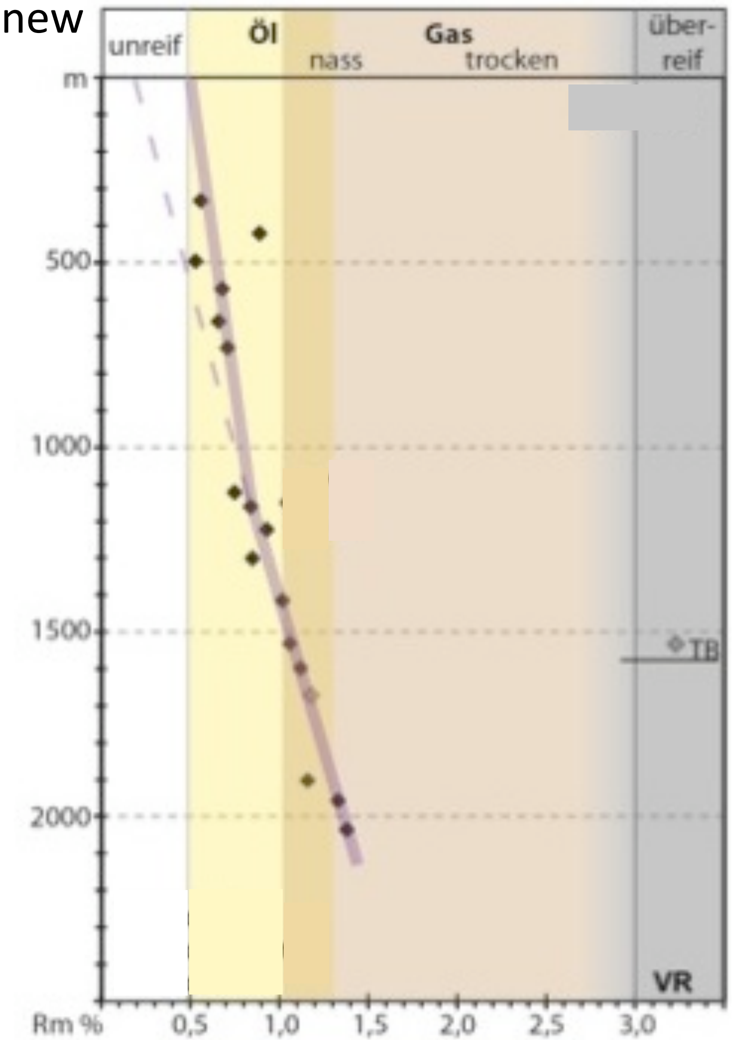
old photometer based VR data vs. new digital image based VR data

old

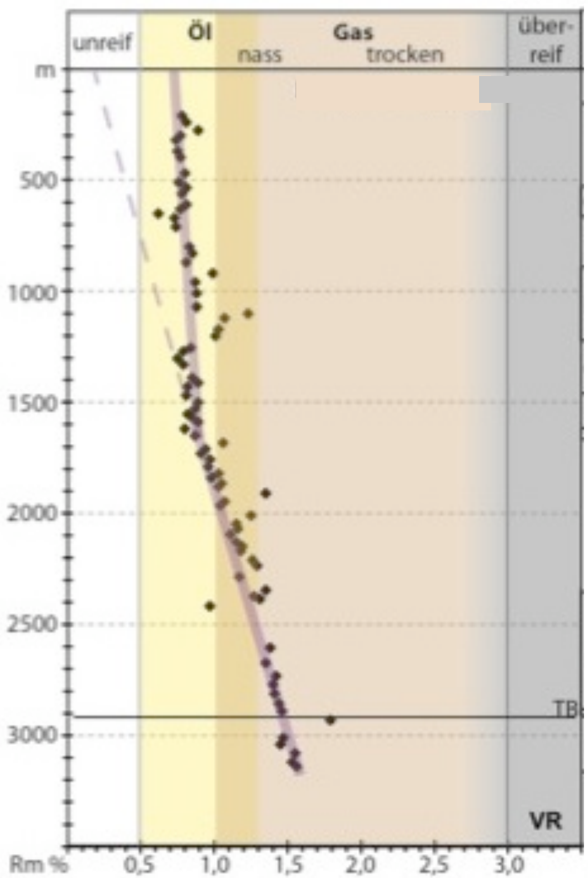


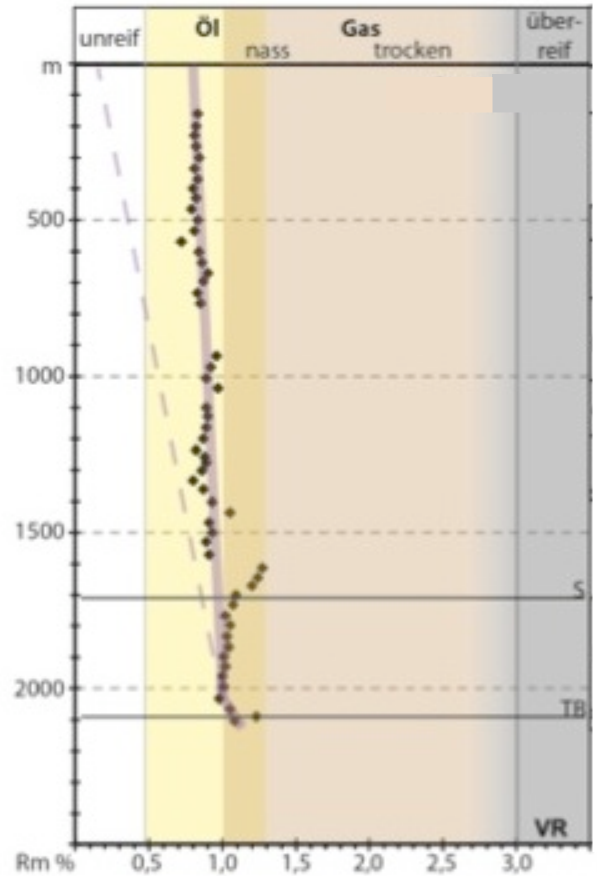
new



Digital image based VR – case studies

High resolution data sets with low internal variation – identification of different paleothermal trends within one sections & short-lived thermal anomalies





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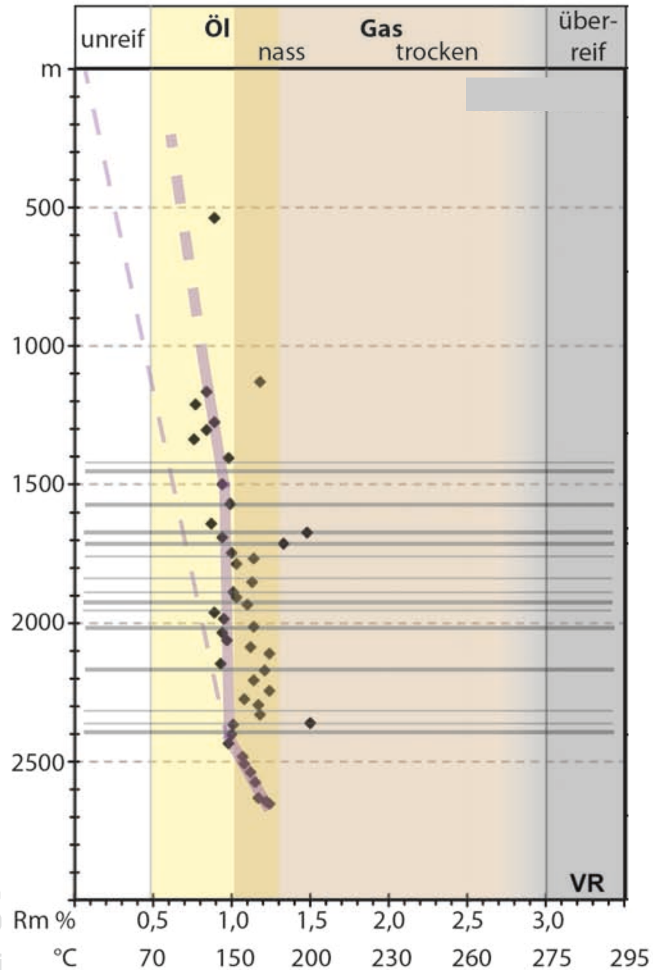
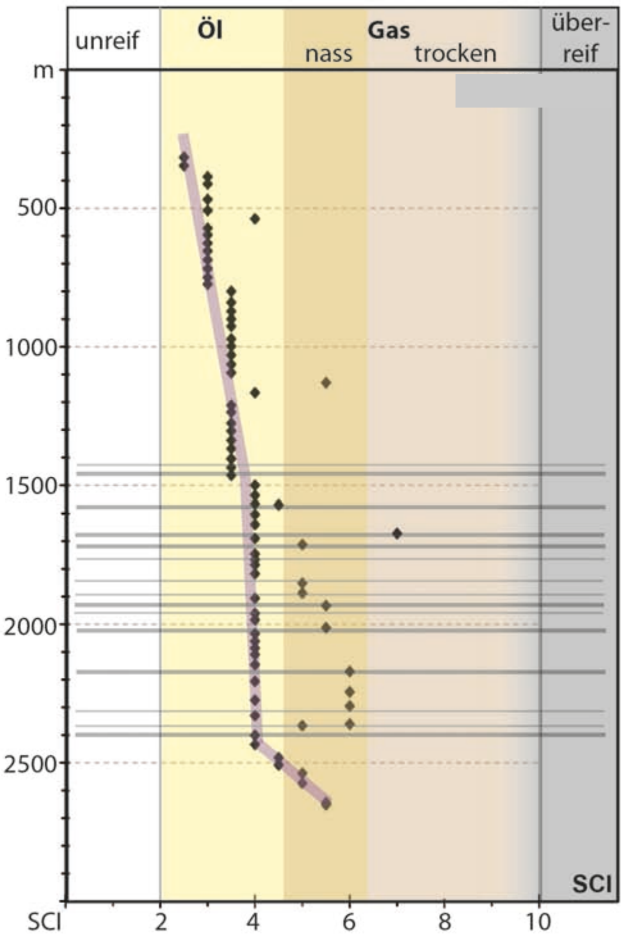
Integrated maturation analysis – case studies

Combination of VR & SCI for independent cross-check of maturation data sets

SCI fills gaps, where no vitrinite is preserved

Identification of several partial paleothermal trends within one well

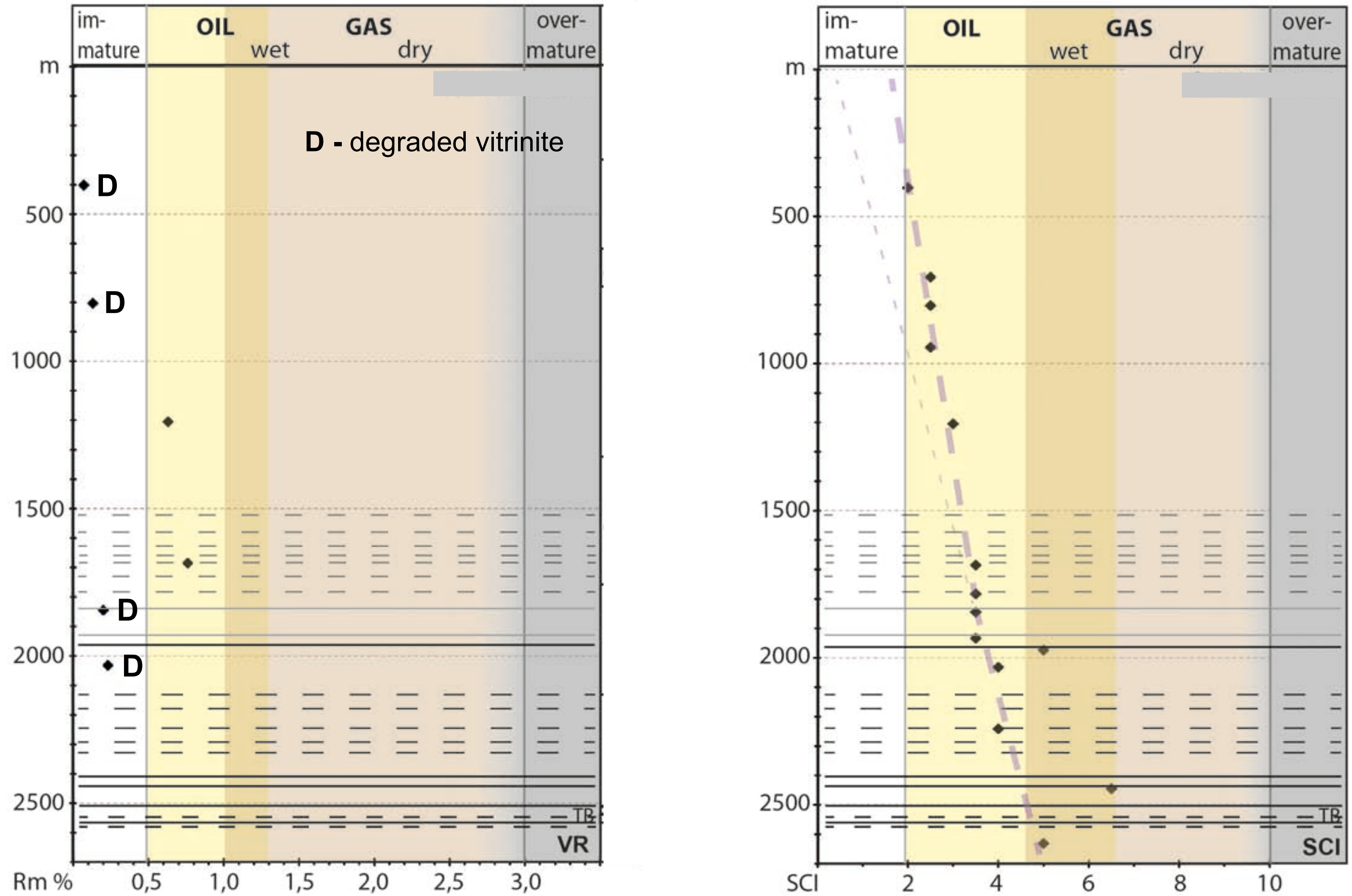




Integrated maturation analysis – case studies

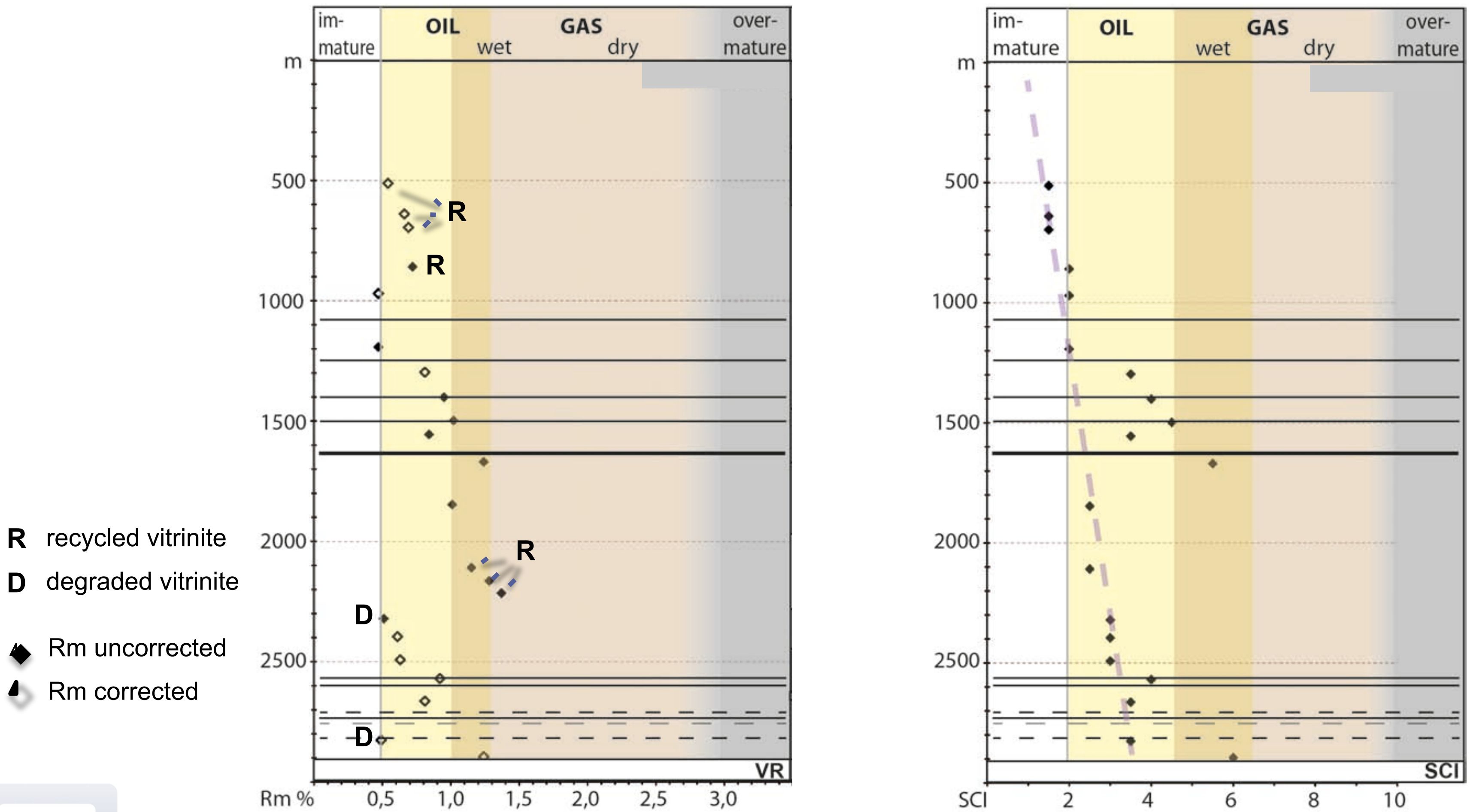
Combination of VR & SCI for independent cross-check of maturation data sets

SCI fills gaps, where no vitrinite is preserved and identifies degraded vitrinite

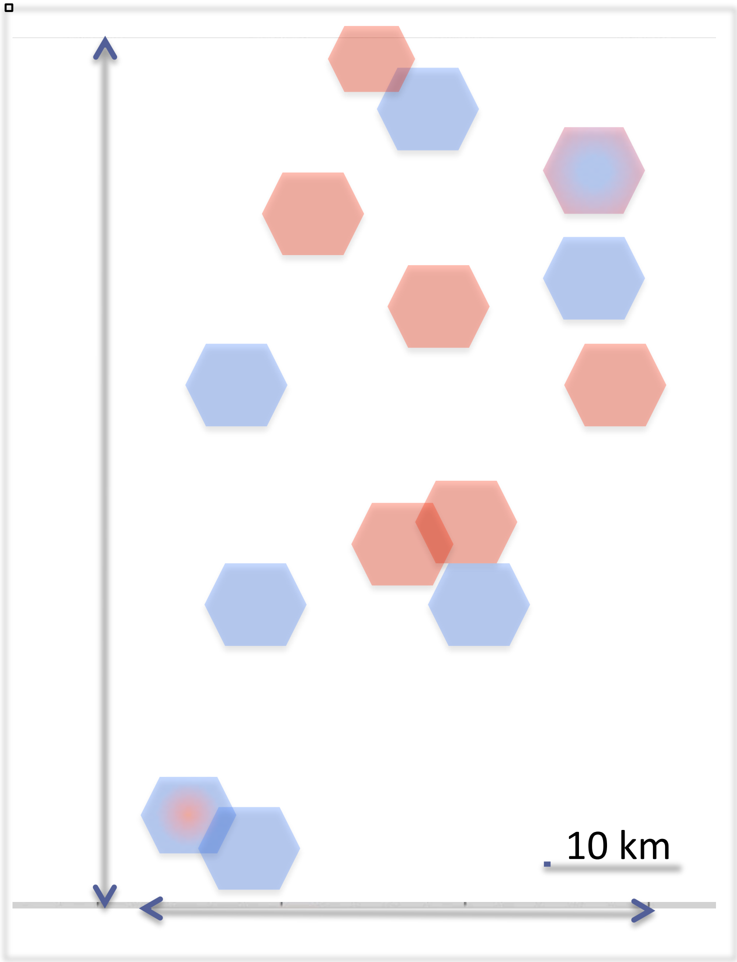


Integrated maturation analysis – case studies

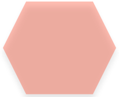
Combination of VR & SCI for cross-check of complex 'chaotic' maturation data sets



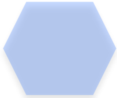
Integrated Maturation analysis – case studies



Integrated maturation analysis for high-resolution spatial distribution of paleo-temperatures & maturation pattern



Secondary thermally overprinted (magmatic intrusions / hydrothermal fluid systems)



Primary subsidence controlled (with restricted intervals effected by secondary heating (blue-red))

Benefits for HC Exploration

- Digital image based VR analysis enables measurements of small vitrinite grains down to pixel-size (<10µm) without any side effects
- Strongly improved interpretation of VR data sets of mixed kerogens by identification of degraded & recycled vitrinite vs. in-situ vitrinite populations
- better separation of vitrinite from vitrinite-like particles
- nevertheless VR analysis is limited by availability of vitrinite - not available before middle Silurian and rare in certain sedimentary settings
- Palynomorph colour indices are good alternatives for analysis of organic maturation & hydrocarbon generation levels, when vitrinite is absent
- Integrated maturation analyis (VR & Palynomorph colours) minimizes uncertainty of maturation data by maximum application to different geological settings and cross-checking the results of both methods