Application of excitation-emission fluorescence microscopy to thermal maturity of geological samples

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Outline

Objective and Geologic Background – the why
Petrographic Thermal Indices and Minutia – the how
Excitation-Emission Fluorescence Microscopy – the how?
Summary and Future Directions – the next thing
Objective: what is the western limit of thermally mature Devonian shale source rocks in the Appalachian Basin?

Ryder et al. 2013, AAPG S&D; Hackley et al. 2013, Fuel; Araujo et al. ms
**Why Important:** What is the source rock?

Why is thermogenic gas the dominant hydrocarbon reservoired in the Devonian?

Where is the oil?

Where do we draw boundaries for unconventional resource assessment?

*Ohio Geological Survey, 2004*
Tasmanites marine algae under ultraviolet illumination

With increasing thermal maturity:
- spectra are red-shifted
- fluorescence intensity increases then extinguishes
- shrinking and cracking develop
- regions of intense fluorescence persist at points of greatest structural deformation (?)

Araujo et al. ms
Ro = 0.45%

Conventional fluorescence microscopy; calibrated to Baranger lamp; reproducible
Laser Confocal Microscopy

- Argon laser, 458 nm excitation @ BGR
- Powerful imaging tool
- High resolution
- Extends observations of organic fluorescence to higher maturity
- Images are false color
- Spectral data are reasonably consistent with conventional spectra from Hg illumination and equiv.

False color laser confocal images, Jolanta Kus BGR
10 nm steps in excitation (470-670 nm)
5 nm steps in emission (490-785 nm), 10 nm bandwidth

white light laser (470 nm-670 nm)
Huron 1 – lowest maturity; $R_o$ 0.45, $\lambda_{\text{max}}$ 519, $T_{\text{max}}$ 439 (RE2)

Conventional fluorescence microscopy:
excitation @ 365 nm; emission @ LP 420 nm
Huron 4 – intermediate maturity; $R_o$ 0.53, $\lambda_{\text{max}}$ 611, $T_{\text{max}}$ 448 (RE2)
Huron 3 – highest maturity; $R_o \ 0.62$, $\lambda_{\text{max}} \ 610$, $T_{\text{max}} \ 440 \ (RE2)$
Huron 4 – intermediate maturity; $R_o$ 0.53, $\lambda_{max}$ 611, $T_{max}$ 448 (RE2)

brighter regions, blue shifted
dimmer regions, red shifted
Summary

Laser scanning confocal microscopy applied to geological materials:

**So what?**
- Improved imaging – high resolution
- Comparable spectra to conventional fluorescence microscopy
- Characterization of thermal maturity
- White light laser allows collection of broad ‘spectrum’ of spectral data – the EEM

**Yeah .... but,**
- Comparable spectra to conventional fluorescence microscopy – high instrument costs, long scanning times
- What do the EEMs tell us?
Future Directions

• What do the EEMs tell us?

- Preliminary μ-FTIR data indicate aliphatic chains become shorter & more branched, oxygenated groups decrease
- What will XPS tell us about CNOS abundance & speciation? \(^{13}\)C NMR? Kerogen concentration is challenge!
- Are the EEM data reproducible?
- Can the molecular data be tied to the EEM?

**CH\(_2\)/CH\(_3\)**

**Aliphatic stretch/Oxygenated groups**

μ-FTIR data courtesy Maria Mastalerz, IGS
Thank You!

image courtesy of Jolanta Kus, BGR