Finalization of the Confocal Laser Scanning Microscopy (CLSM) Working Group

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A working group in Commission II to investigate applications of confocal laser scanning microscopy (CLSM) for organic petrology investigations has finalized with publication of the manuscript "Characterization of bituminite in Kimmeridge Clay by confocal laser scanning and atomic force microscopy" in the International Journal of Coal Geology.

The manuscript is available via Open Access from https://doi.org/10.1016/j.coal.2022.103927 and also from the Commission II working group (WG) webpage https://www.iccop.org/workinggroup/confocal-laser-scanning-microscopy-clsm/.

A report detailing the full history and results from the WG also is available from the Commission II WG webpage. The working group investigated the application of CLSM to an organic-rich (44 wt.% TOC), thermally immature sample (VR_o 0.42%) of the Kimmeridge Clay Formation. CLSM imaging and spectroscopy and atomic force microscopy (AFM) were used to characterize bituminite.

Key findings from two- and three-dimensional CLSM imaging included:

- incomplete blocking of reflected laser light from low-absorbing sulfide and fusinite inclusions in bituminite;
- halos of decreased fluorescence intensity around radioactive minerals in bituminite;
- the presence of sporinite and *Botryococcus* (interpreted identification) as particulate constituents of bituminite;
- and the red-shift of sulfide reflectance and bituminite fluorescence emanating from below the sample surface as compared to light from its surface.

Key findings from CLSM spectroscopy included:

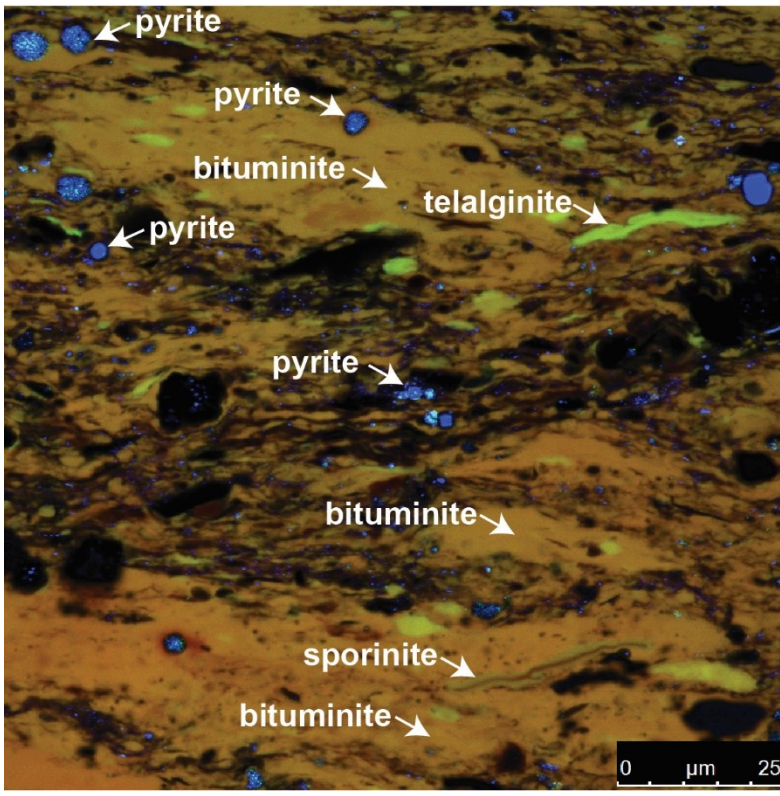
- color blue-shift from positive alteration via laser-induced photo-oxidation of bituminite;
- blue-shift associated with higher fluorescence intensity regions in bituminite, probably due to differences in composition, e.g., related to particulate constituents or degradation products thereof;
- differences in spectroscopic data collection procedures and reported fluorescence emission parameters for bituminite, highlighting the need for standardization in fluorescence spectroscopy;
- and the prediction of solid bitumen reflectance via calibration to an extant dataset.

WG members also applied AFM to bituminite in the Kimmeridge Clay sample, from which the key findings were:

- increased surface flattening from broad ion beam (BIB) milling which resulted in higher reflectance of bituminite;
- the differential erosion of bituminite during BIB milling compared to harder micro- and nanoscale quartz and sulfide inclusions;
- the exposure by BIB milling of nano-sulfides embedded in bituminite which resulted in decreased surface flatness.
- and the magnitude of bituminite surface deviation from perfect flatness was dependent on the scale of observation.

The findings illustrate the utility of CLSM (and AFM) as research tools in organic petrology, and suggest that future workers could leverage the investigative properties of both approaches in combined AFM-CLSM studies of sedimentary organic matter.

Persons interested in CLSM and AFM applications to sedimentary organic matter are encouraged to contact Paul Hackley phackley@usgs.gov and Jolanta Kus Jolanta.kus@bgr.de.



CLSM composite photomicrograph of bituminite in Kimmeridge Clay Formation showing inclusions of pyrite, telalginite, and sporinite.

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