[PS]Chemostratigraphy, Geochemistry, and Petrography of the Anna Shale and Pyrite Suns of the Illinois Basin*

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Abstract

Petroleum play evaluation requires the characterization of an effective source rock by delineating the amount of reactive organic matter and its maturity. The geochemical and petrographic analyses used in this study of the Anna Shale in the Illinois Basin are the same used to characterize the generative potential of source rocks. The generative potential is determined by the paleo-redox conditions and depositional environment that preserved organic matter.

The vertical variation in composition of organic matter of the Anna Shale is being determined using petrographic analysis and Rock-Eval pyrolysis on four cores provided by the Illinois State Geological Survey. Carbon and sulfur analysis is being used to estimate the paleo-redox conditions in the depositional environment during accumulation of organic matter. The relationship between total organic carbon and sulfur deposited as pyrite is a result of the paleo-redox conditions that also constrain the breakdown and accumulation of organic matter. Trace element analysis is a widely-used proxy for paleo-redox conditions. X-Ray Fluorescence measurements taken at 1cm intervals for each core have been used to produce a trace element concentration profile for the assessment of redox conditions during deposition of the Anna Shale.

The synthesis of various methods for determining source rock quality and conditions of deposition will not only provide a multi-perspective assessment and interpretation, but also a frame of comparison for individual methodologies.

Disk-shaped pyrite concretions (pyrite suns) found at the base of the Anna Shale are being investigated using X-Ray diffraction and electron probe microanalysis on pyrite suns collected from southern Illinois coal mines. Sedimentological evidence including unrestricted growth from a median layer and soft sediment deformation indicate crystallization in soft sediments. Mineralogical and trace element data are providing insights into mineral composition, process of crystal growth, and formation of pyrite suns.

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Chemostratigraphy, Geochemistry, and Petrography of the Anna Shale and Pyrite Suns of the Illinois Basin

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1. Introduction

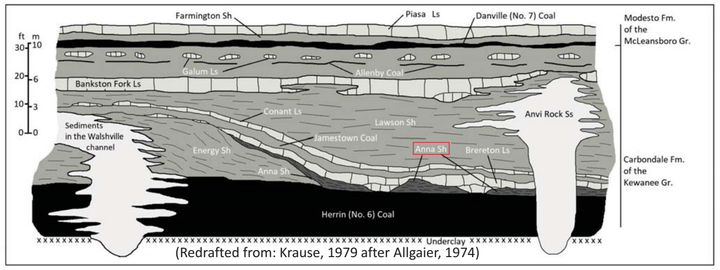
Anna Shale

- Middle Pennsylvanian
- Black, organic-rich fissile shale
- Occurs in "irregular winding lenses"
- Range of thicknesses 0-5'

(Krause, 1979; Palmer, 1979)

Pyrite Suns

- Disk-shaped pyrite concretions
- Occur at the contact between the Herrin No. 6 Coal and the Anna Shale
- Typically 9 cm in diameter



(Redrafted from: Krause, 1979 after Allgaier, 1974)


9 cm

Objectives

- Assess the paleo-redox conditions under which the Anna Shale was deposited by analyzing trace elements, TOC, and C/S relationships
- Determine sources of organic matter in the Anna Shale through petrographic analysis of maceral content
- Assess the source rock quality of the Anna Shale using Rock-Eval pyrolysis
- Investigate trace element content of pyrite suns as they may relate to their formation and redox conditions

2. Methods

Samples

- Four cores were obtained from the Illinois State Geological Survey Samples Library
- Cores were drilled in northeastern Washington County, IL
- Seven roof shale samples were collected from the Prairie Eagle underground mine
- Approximately 12 pyrite suns were collected from the same mine

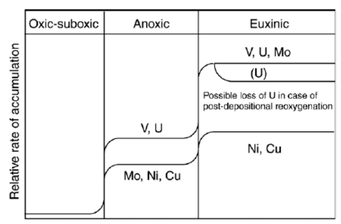
Analytical Methods

- A handheld XRF instrument was used to scan three cores at a 1 cm intervals
- Multiple intervals were selected from each core based on concentrations of redox sensitive elements for TOC/Rock-Eval pyrolysis, C/S analysis, and petrographic analysis

3. Results

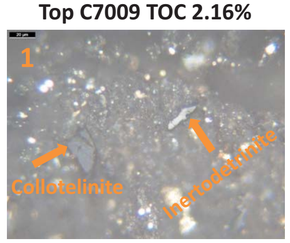
Chemostratigraphy

- Mo and V enrichments correlate with TOC below certain threshold (~10% TOC for Pennsylvanian)
- Correlation disappears above this threshold and significant Mo and V enrichments occur
- Threshold marks anoxic-euxinic boundary
- Threshold in cyclothem black shales is ~10%
- V/Cr and Ni/Co ratios from Jones and Manning, 1994

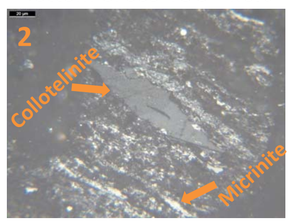


(Tribovillard, 2006; modified from Algeo and Maynard, 2004)

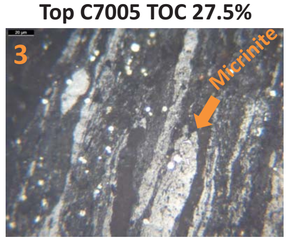
Top C7009 TOC 2.16%



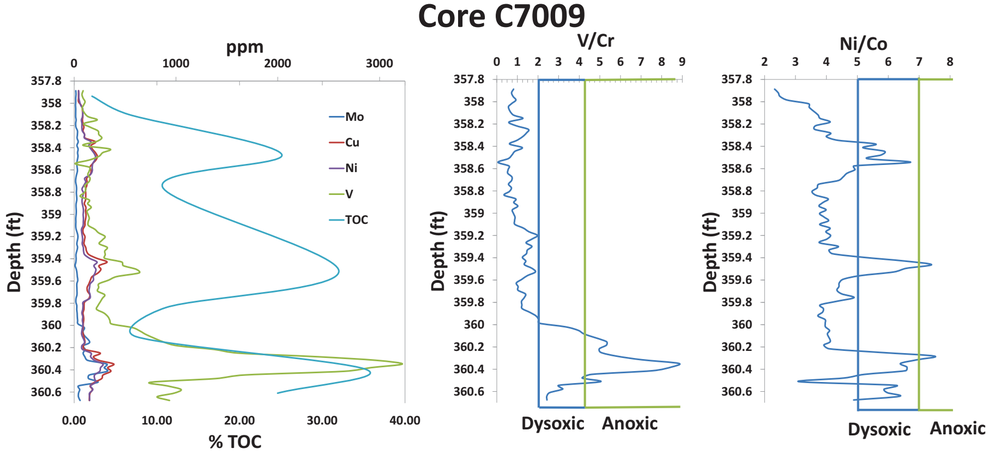
Bottom C7009 TOC 24.6%



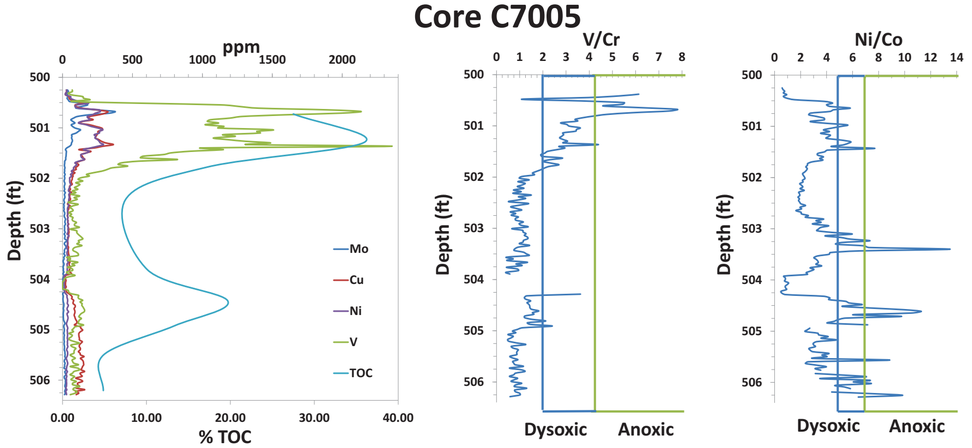
Top C7005 TOC 27.5%



Core C7009



Core C7005



4. Discussion

Chemostratigraphy

- Significant Mo, V, and other redox sensitive element enrichments correlate with the highest TOC contents
- Significant increases in Mo and V concentrations at these intervals may suggest euxinic conditions during deposition
- Ni/Co and V/Cr ratios show agreement that anoxic conditions may have been present at the highest TOC intervals
- V/Cr and Ni/Co ratios suggest dysoxic to anoxic conditions during deposition of other high TOC intervals; an increase in Mo and V enrichments is not observed at these intervals

Organic Petrography

- Large amounts of micrinite are observed in high TOC intervals as both disseminated and banded textures (Images 2 & 3)
- Collotelinite and inertodetrinite is observed in both high TOC intervals and low TOC intervals (Images 1&2)

Remaining Analysis

- XRD of pyrite suns at SIU to determine mineral composition
- EPMA and LA-ICP-MS at SIU of pyrite suns at University of Kentucky to investigate variations in trace element concentrations as they may provide information on conditions during crystallization

5. Acknowledgements

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