Theme 6: Unconventional: Emerging and Mature North American Plays (EMD/AAPG)
Session Day: Monday, April 3, 2017 Presentation Time: 11:30 AM Location: General Assembly A

Chronostratigraphy, Correlation, and Depositional History of the Marcellus shale in the Central Appalachian Basin: A study of Inorganic Geochemistry, Stable Isotopes, and Magnetic Susceptibility Data from Pennsylvania and West Virginia

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Five drill cores of Middle Devonian sedimentary rock from the central Appalachian Basin have been sampled at 1.5 foot intervals for inorganic (XRF) and stable isotope ($\delta^{13}C_{org}$) geochemistry along with bulk magnetic susceptibility data collected at 0.5 foot intervals. This data is employed here to resolve the depositional and diagenetic character of the uppermost Onondaga limestone, Marcellus shale, and overlying "Hamilton" units in West Virginia and southern Pennsylvania.

A hierarchical cluster analysis reveals two major element associations, one likely controlled by clastic mineralogy (Na, Zr, Ti, K, Al, Ga, Rb) and another reflecting authigenic components such as biogenic apatite (P), carbonates (Ca, Mg, Mn), barite (Ba, S), and proxies for organic matter and low oxygen depositional environments (V, Mo, U, Cu, Ni). The abundance of silica is also correlated these redox sensitive indicators, though the reasons for this remain unclear. It may relate to diagenetic mineralization by low pH pore-waters; a finding consistent with exceptionally high DOP and low clay content.

A detailed chemostratigraphic correlation has been generated based on key element abundances and ratios (Th/U, Na/Al, Zr/Al, Cr/Al, and the relative enrichment of U). This framework suggests that lower subdivisions onlap the Onondaga Formation to the northwest. Exceptionally low $\delta^{13}C_{org}$ in this lower section (Union Springs) are consistent with deposition during the late Eifelian Kačák Event. Within this chronostratigraphy, upward-rising bulk magnetic susceptibility values that likely reflect the shift from transgression to highstand in the early Givetian, a pattern echoed by Th/U values. These quantitative data may be useful for calibrating high resolution sequence and chronostratigraphic models for the Marcellus shale.

Session Title: Theme 6: Unconventional: Emerging and Mature North American Plays (EMD/AAPG)
Session Day: Tuesday, April 4, 2017 Presentation Time: 3:25:00 PM Location: General Assembly A

Characterization and correlation of the Kreyenhagen Fm in the northern San Joaquin Basin, California: a chemostratigraphic perspective.

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Acquisition of bulk inorganic elemental data, and subsequent chemostratigraphic characterization and correlation have become routine analyses in resource plays over the last 10 years. This analysis allows detailed information about depositional facies, mineralogy, redox conditions and sediment provenance to be gathered and placed in stratigraphic context. In this study, the same approach is used to help define, characterize, and correlate the Kreyenhagen Formation.

The Kreyenhagen Fm is Middle-Late Eocene in age,-and comprises siliceous shales and siltstones with occasional carbonates. Over the last five years the Kreyenhagen Fm has become a notable target within the San Joaquin Basin, for both conventional and unconventional exploration and development. However, data relating to the Kreyenhagen Fm is limited. Unlike many other onshore US shale plays, the Kreyenhagen Fm is not overburden to any geographically extensive and prolific conventional reservoirs and has never been extensively drilled. As such, the interval is less extensively studied and has less data and samples available for analysis than other, more “famous” US shales. In this paper we aim to answer three primary questions; A) Can the Kreyenhagen Fm be characterized using elemental data? B) What does the elemental data tell us about the depositional environments? C) How laterally homogenous is the Kreyenhagen Fm?

Data gathered from cutting samples in 7 wells within the northern San Joaquin Basin show that the Kreyenhagen Fm can be readily differentiated from over and underlying formations using a chemostratigraphic approach. Additionally, it is possible to subdivide the Kreyenhagen Fm into a series of chemostratigraphic units that reflect differing redox conditions, facies, biogenic silica contents and abundances of detrital minerals, suggesting that this is a relatively heterogeneous and dynamic depositional system, in a stratigraphic sense. Detailed core analyses, integrating elemental and magnetic susceptibility analyses confirm that not only do these sequences show heterogeneity down to a 6-12 inch scale, but that they also show a certain degree of cyclicity at this scale. Furthermore, the geochemical units defined within the Kreyenhagen Fm, appear to be laterally continuous, allowing the chemostratigraphic correlation to be confidently applied to wells analyzed across the northern San Joaquin Basin. Importantly, this work also provides an understanding of spatial and stratigraphic heterogeneity within the Kreyenhagen Fm and allows for comparison to other US shale plays.

Session Title: Theme 11: Future of Energy: Exploration and Essential Tools for the Next Generation
Session Day: Monday 3 April 2017 – 1:30 PM – 5:00 PM, Location: Hall D-E

Organic carbon isotopes and Silurian chronostratigraphy in eastern Europe

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The Late Ordovician and Silurian periods are punctuated by disturbances of the global climate and oceanographic system; phenomena identified by significant, yet stratigraphically narrow positive shifts in stable carbon isotope ratios ($\delta^{13}C$). Given the widespread distribution and highly isochronous nature of these signals, they have been widely employed for chronostratigraphy in sequences where biostratigraphic data are limited. Globally recognized patterns have recently been used to create generalized $\delta^{13}C$ curves that have been integrated with the geologic timescale, which permits the calibration of global events and correlations with unprecedented resolution. However, much of this prior work is limited to inorganic $\delta^{13}C_{carb}$ data derived from carbonates, largely limiting these studies to calcareous sequences. This study presents new $\delta^{13}C_{org}$ data from biostratigraphically well-constrained intervals through the Hirnantian to Ludfordian at localities in Poland.

The resulting $\delta^{13}C_{org}$ curves show distinct zones of heavy values that appear to be coincident with the positive excursions of the Hirnantian (HICE) and lower Sheinwoodian ("Ireviken"). Although less conclusive, Homerian ("Mulde") and lower Ludfordian excursions may also be recognized, along with several intermediate features of the global composite curve, such as a sharp negative shift in values above the HICE, steadily rising-upward values through the upper Telychian, and gently declining-upward values that follow the "Ireviken" excursion.