[PS]Applying Regional Chemostratigraphic Variability to Refine Sequence Stratigraphic Frameworks within the Woodford Shale, Oklahoma*

Bryan W. Turner[1], Jessica A. Tréanton[1], and Roger M. Slatt[1]

[1]University of Oklahoma, Norman, OK, USA (bwturner@ou.edu, jessica.treanton@ou.edu)

Abstract

The Woodford Shale provides an opportunity to test recent advances in handheld XRF (HHXRF) technology to develop sequence stratigraphic frameworks by comparing chemostratigraphic profiles directly to gamma ray logs and measured stratigraphic sections obtained from the same locations. Gamma ray profiles allow a direct integration of these newly obtained chemostratigraphic profiles into previously interpreted sequence stratigraphic frameworks. One field site and three cores of the Woodford Shale have been scanned using the HHXRF to develop a preliminary analysis of the regional variability of chemostratigraphic profiles for this formation.

Three cores from Caddo, Washington, and Pottawatomie Counties in Oklahoma and one outcrop at the Hunton Anticline Quarry (HAQ) in Murray County, OK represent both proximal and distal environments of the Woodford Shale. Clean surfaces at each area are scanned at one-foot intervals using the HHXRF to determine the elemental profiles. At the same resolution, a gamma ray profile is scanned using a GR scintillometer or core spectral gamma ray. The lithologic description, gamma ray profile, and elemental profiles are then used to develop the sequence stratigraphic interpretation.

Correlations based on regional scale variations in chemostratigraphic proxies show an overall increase in sedimentation in proximal settings with a decrease in sedimentation in distal settings. Drops in continentally derived sedimentation are interpreted from dilution of the Zr and Ti signals, associated with clastic sedimentation, relative to the concentration of K and Al, which are associated with clay mineral accumulation. All these elements are regarded as relatively immobile elements. In the distal setting, the chemostratigraphic ratios between clastic and clay proxies show a dilution of Ti and Zr between 10-60% in the upper Woodford relative to the lower Woodford, while in the proximal setting these ratios are concentrated up to 12-15% in the upper Woodford relative to the lower. These changes are indicative of a landward shift in sedimentation.

APPLYING REGIONAL CHEMOSTRATIGRAPHIC VARIABILITY TO REFINE SEQUENCE STRATIGRAPHIC FRAMEWORKS WITHIN THE WOODFORD SHALE, OKLAHOMA

TURNER, Bryan W.[1]*, TRÉANTON, Jessica A.[1]+, and SLATT, Roger M.[2]

(1) ConocoPhillips School of Geology and Geophysics, University of Oklahoma, 100 East Boyd St., Office 912, Norman OK 73019 (2) ConocoPhillips School of Geology and Geophysics, University of Oklahoma, 100 East Boyd St., Office 934, Norman OK 73019
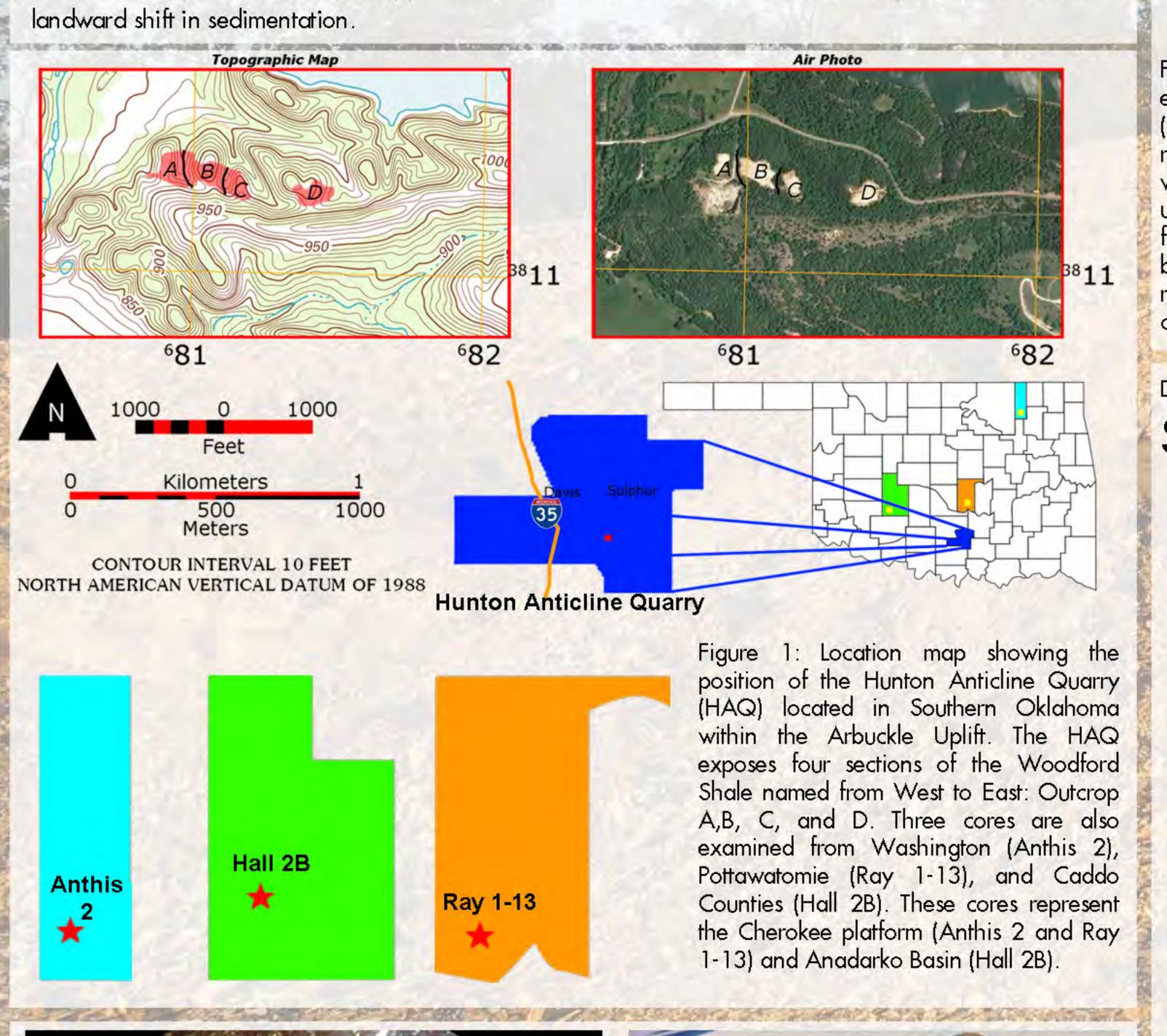•*bwturner@ou.edu +jessica.treanton@ou.edu

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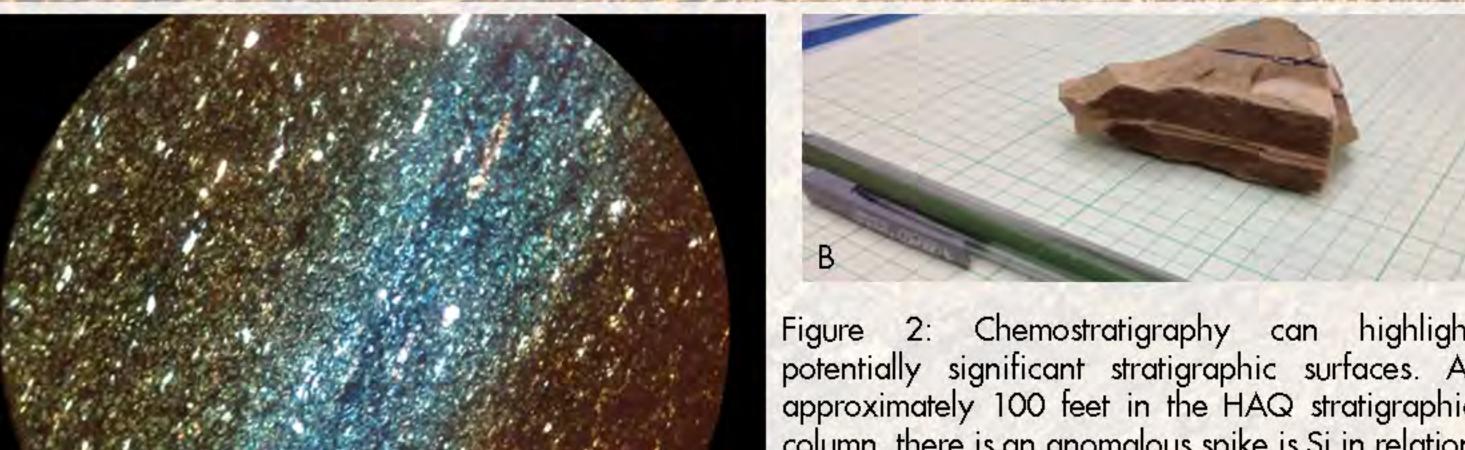4-5 September 2014, Houston TX

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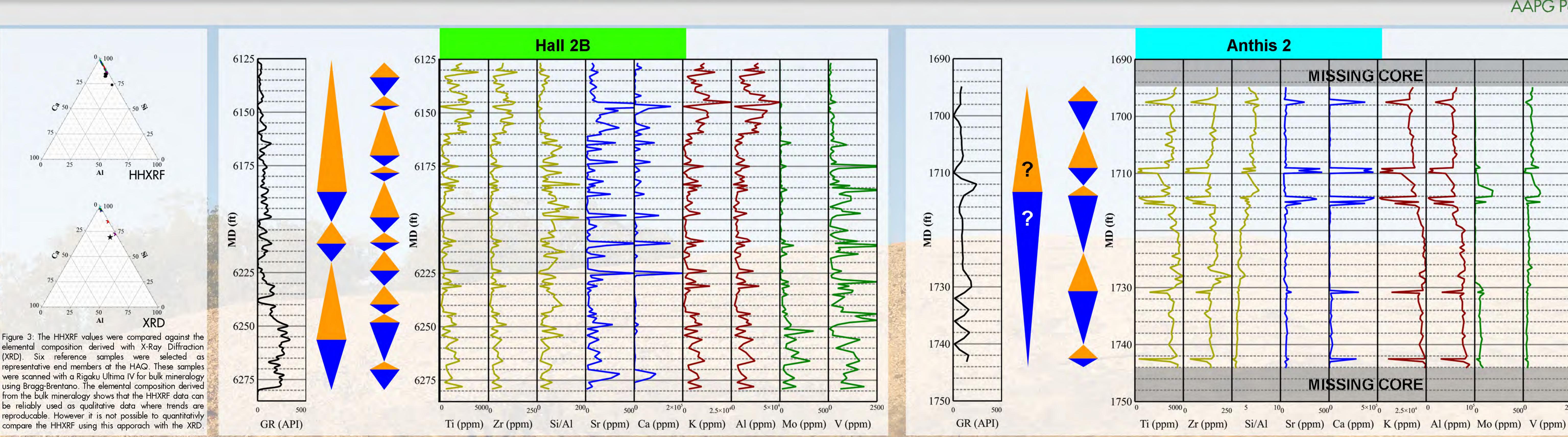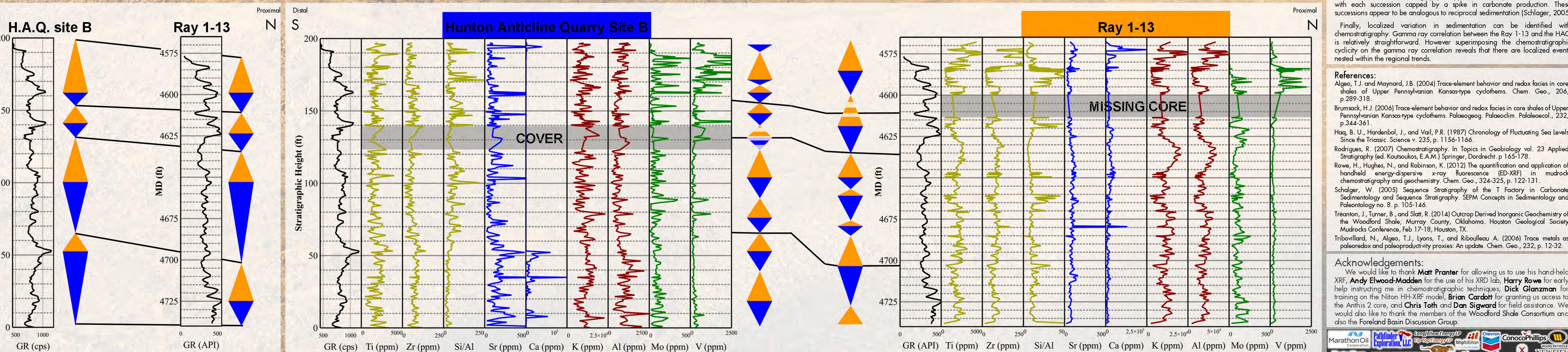
Figure 3: The HHXRF values were compared against the elemental composition derived with X-Ray Diffraction (XRD). Six reference samples were selected as representative end members at the HAQ. These samples were scanned with a Rigaku Ultima IV for bulk mineralogy using Bragg-Brentano. The elemental composition derived from the bulk mineralogy shows that the HHXRF data can be reliably used as qualitative data where trends are reproducible. However it is not possible to quantitatively compare the HHXRF using this approach with the XRD.

Figure 1: Location map showing the position of the Hunton Anticline Quarry (HAQ) located in Southeast Oklahoma within the Arbuckle Uplift. The HAQ exposes four sections of the Woodford Shale named from West to East: Outcrop A, B, C, and D. Three cores are also examined from Washington (Anthis 2), Pottawatomie (Ray 1-13), and Caddo Counties (Hall 2B). These cores represent the Cherokee platform (Anthis 2 and Ray 1-13) and Anadarko Basin (Hall 2B).

Figure 2: Chemostratigraphy can highlight potentially significant stratigraphic surfaces. At approximately 100 feet in the HAQ stratigraphic column, there is an anomalous spike in Si in relation to Al. This is indicative of SiO₂ deposition. As Ti and Zr are also low at this horizon, it is interpreted to be biogenic in origin, indicating a depositional hiatus. At several of these horizons, there is coincident spike in carbonate proxies (Ca and Sr). This could be analogous to reciprocal sedimentation (Schlager 2005) where carbonate accumulation indicates clastic sedimentation is sequestered landward. A) A thin section showing the biogenic quartz. B) The hand sample showing the biogenic quartz horizon.

Hall 2B

Anthis 2

H.A.Q. site B / Ray 1-13

Hunton Anticline Quarry Site B

Ray 1-13

Discussion:

During the course of sedimentation, certain elements occur in high abundances within continentally derived sediments and other elements are associated with clay minerals (Rodrigues, 2007). By comparing these elemental concentrations, it is possible to estimate trends of increasing and decreasing sedimentation rates and approximate the redox state at the sediment water interface (Algeo and Maynard, 204; Brumsack, 2006; Tribovillard et al., 2006). However, it is important to utilize multiple elemental proxies (Rowe et al., 2012), preferably of low mobility, to limit the possibility of diagenetic overprinting.

There are also several instances where the higher frequency cyclicity observed within the chemostratigraphic profiles is out of phase with the longer trends observed within the gamma ray profiles. These instances are interpreted to be examples where localized depositional conditions differ from the overall trends within the basin. This would result in localized cyclicity which has long been understood to be a part of sequence stratigraphic frameworks (e.g. Haq et al., 1987).

Finally, subtle surfaces of non-deposition have been interpreted to occur on horizons where carbonate proxies (Ca and Sr) peak or where the Si/Al ratio peaks while other continental sedimentation indicators remain constant.

Conclusions:

Three cores from Caddo, Washington, and Pottawatomie Counties in Oklahoma and one outcrop at the Hunton Anticline Quarry (HAQ) in Murray County, OK represent both proximal and distal environments of the Woodford Shale. The lithologic description, gamma ray profile, and elemental profiles are used to develop the sequence stratigraphic interpretation. Regional correlations are primarily based on Gamma Ray profiles. Application of chemostratigraphy can reveal additional detail to help clarify correlations where ambiguity may be present (Tréanton et al., this conference).

Nested cyclicity has long been understood to be a component of sequence stratigraphy (e.g. Haq et al., 1987). The Gamma ray log from the core Hall 2B reveals that there is an overall cleaning upward succession. This can be interpreted as an overall progradation of sediments associated with a regression of the shoreline. However, chemostratigraphy clearly shows that each of the shallowing upward cycles is composed of shorter periods of localized rises and falls in stratigraphic base level.

Chemostratigraphy can also reveal important details that may be absent from traditional well logs. The Anthis 2 well log shows a gamma ray log with very little character. When chemostratigraphy is applied, several cycles can be identified, with each succession capped by a spike in carbonate production. These successions appear to be analogous to reciprocal sedimentation (Schlager, 2005).

Finally, localized variation in sedimentation can be identified with chemostratigraphy. Gamma ray correlation between the Ray 1-13 and the HAQ is relatively straightforward. However superimposing the chemostratigraphic cyclicity on the gamma ray correlation reveals that there are localized events nested within the regional trends.

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