Examining the Validity of the Computed Al Curve in Elemental Spectroscopy Logs with X-Ray Fluorescence Techniques in the Marcellus Shale*

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Abstract

Elemental capture spectroscopy logs are used in open hole logging to obtain elemental concentrations in the subsurface. It provides measured concentrations of Si, Ca, Fe, S, Ti and Gd, while Al concentrations are computed from Si, Ca and Fe. The objective of this study was to run X-ray fluorescence (XRF) on cuttings from a vertical well to validate the spectroscopy data-in particular the Al curve. Al is one of a few elements used to study detrital sediment input. This brings into question how representative the computed curve is of the actual amount of Al in the rock. Cuttings samples were collected every 30' over a 1,680' interval and 58 samples were analyzed using XRF. The cuttings are not high resolution like the spectroscopy data; however, comparisons were effective. Initial results showed concentrations of Si and Al were too high relative to the logs in some intervals and too low relative to the logs in other intervals. Typically, the bias between core and log data should be in only one direction, but the overall shape of the curves from the cuttings matched the shape of the logs fairly well. With this in mind, it was noted that Barium concentrations were also extremely high, up to 15wt%. This suggests possible $BaSO_4$ contamination from drilling mud, which could give false XRF readings. To investigate further, cuttings samples were washed more thoroughly a second time and the analysis was rerun. The second washing reduced the amount of Ba in the samples, up to 10wt%; however, there were still significant concentrations of Ba and discrepancies between the cuttings and logs. Plotting the Ba values of both runs and the Ba/S ratio clearly demonstrated that the zone of high Ba coincided with the Ba/S ratio in barite suggesting that the contamination came from $BaSO_4$ in the drilling mud. The high increase was tied to where the drilling mud was switched to OBM. The next step was to correct for $BaSO_4$ in all the elemental data. After doing this, the bias was more consistent across

most of the elements and the comparison between the cuttings and log was greatly improved. Several studies have shown that XRF techniques used for cuttings can give slightly biased results for Al and Si depending on the calibration used. Considering this, it would seem that the spectroscopy data quality looks very good and that the derivation of the Al curve from the measured Si, Ca and Fe seems to be a fair representation of measured Al concentrations in the rock.

Examining the validity of the computed Al curve in elemental spectroscopy logs with X-ray fluorescence techniques in the Marcellus Shale

Erin Walker, Seneca Resources & Susan Herron, Schlumberger

Objective and Conclusions

- Objective:
  - Determine the validity of log derived Al to facilitate in improving our interpretation of depositional environments.

- Conclusion:
  - Spectroscopy logs provide a good representation of measured Al in the rock.

Outline

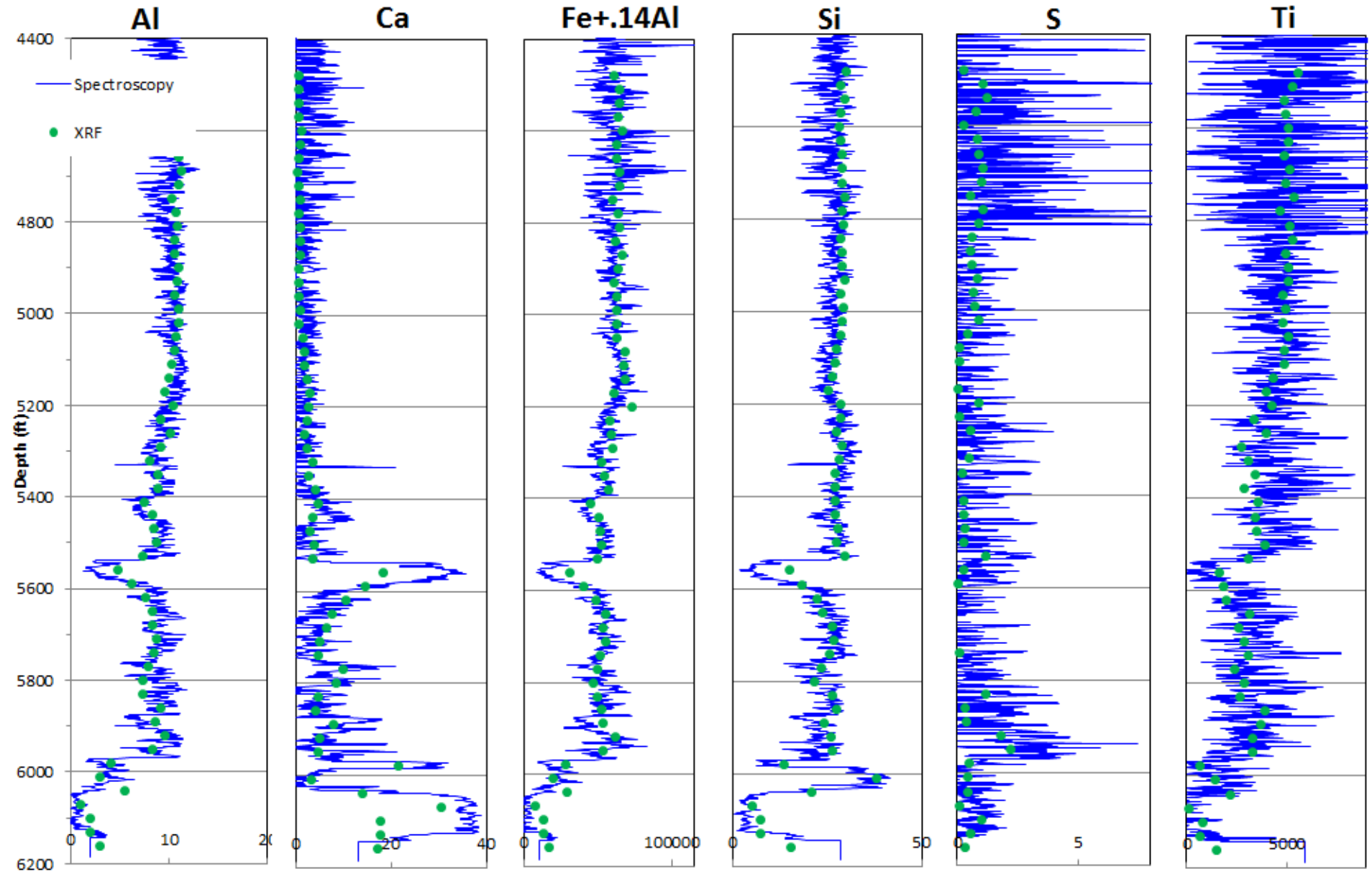
- Objective
- Importance
- Problem
- Goal
- Observations
- Elemental comparisons
- Conclusions

Objective

- Determine the validity of log derived Al concentrations
- Compare Al concentrations from both XRF and elemental capture spectroscopy
  - Need to consider all elemental concentrations (spectroscopy)
- Validity of spectroscopy data

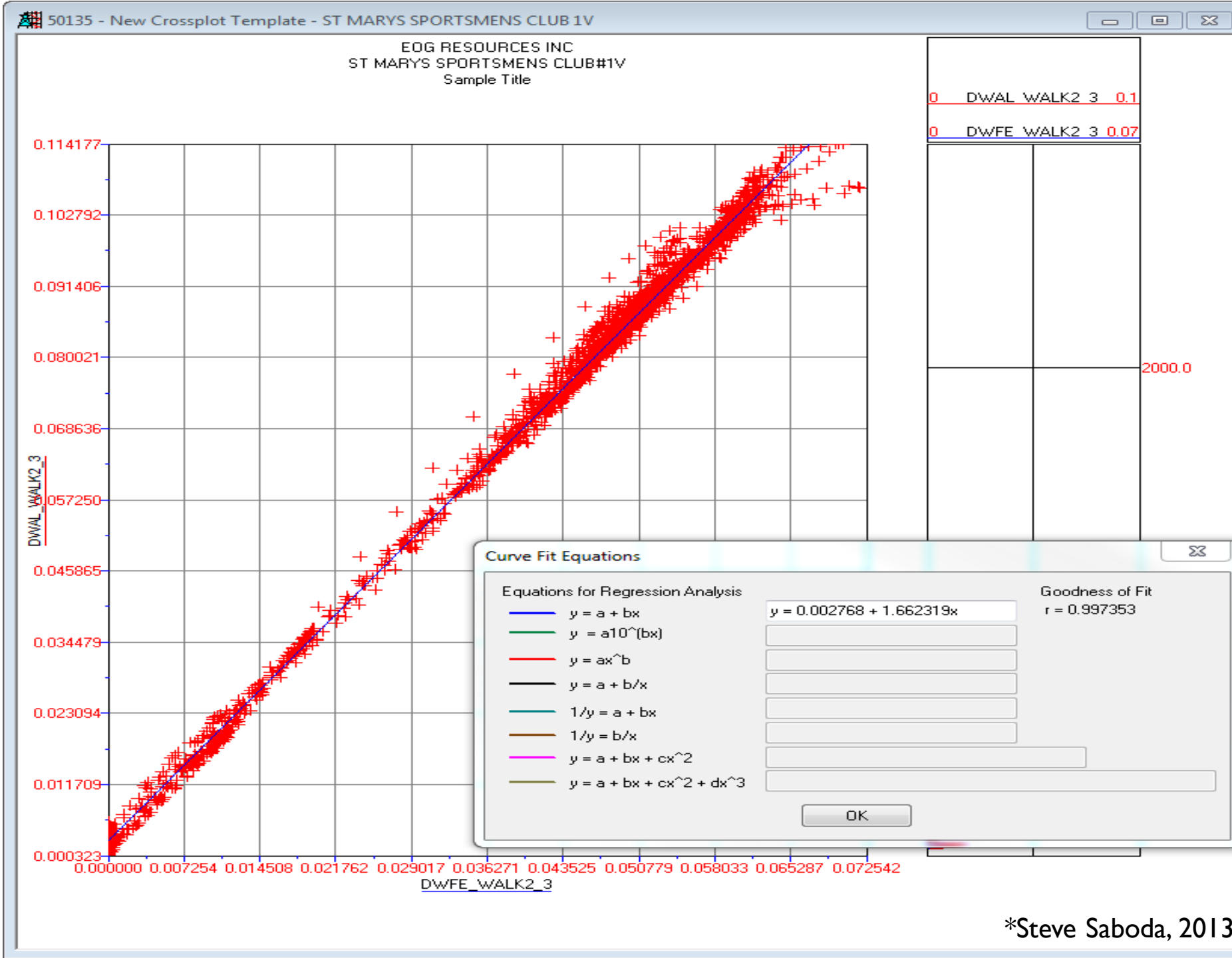
- **Importance**:
  - Proxy for detrital sediment input and organic productivity.

Quick look comparison of elemental capture spectroscopy elements

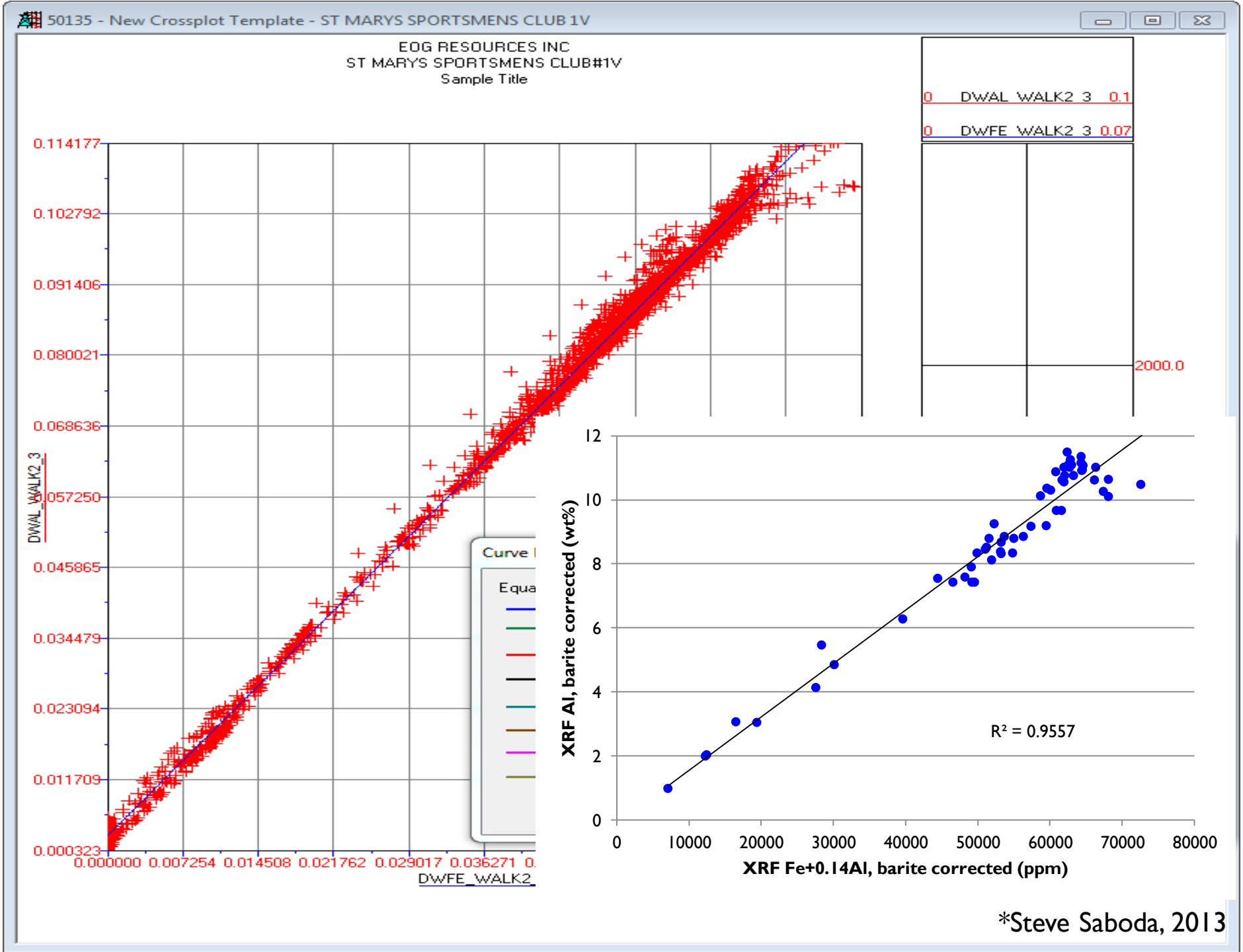


XRF: Aluminum Curve Comparison

- **Problem:**
  - Al is derived from measured Fe, Ca, and Si concentrations.
  - Regression analyses show an R^2=0.99
  - Is the Al curve realistic?



*Steve Saboda, 2013



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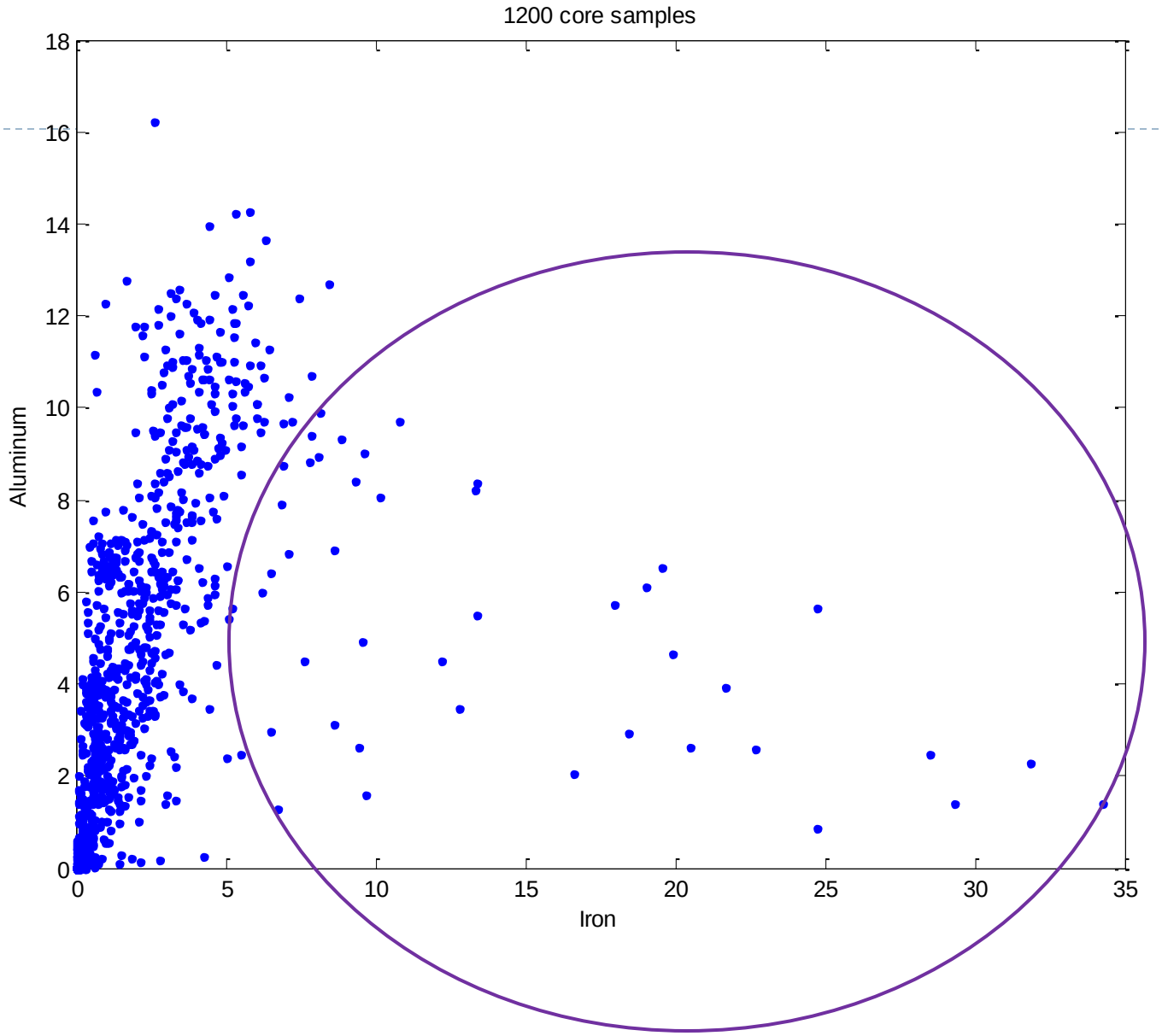
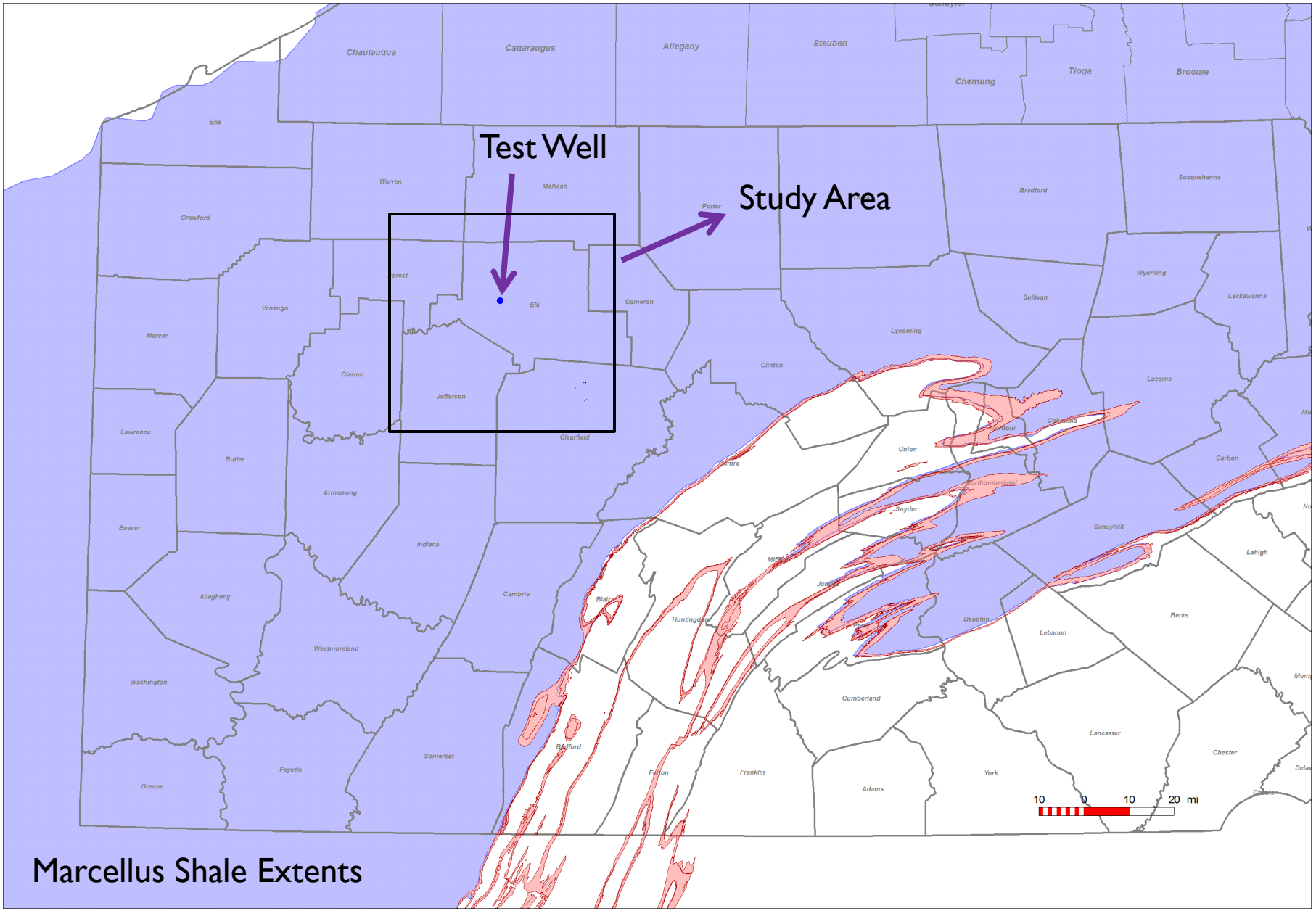

1200 core samples
Aluminum
Iron
0
2
4
6
8
10
12
14
16
18
0
5
10
15
20
25
30
35

XRF: Aluminum Curve Comparison

- **Problem**:
  - Al is derived from measured Fe, Ca, and Si concentrations.
  - Regression analyses show an R^2=0.99
  - Is the Al curve realistic?

- **Goal**:
  - Use XRF on vertical cuttings
  - Compare spectroscopy elements to measured elemental concentrations

- **Procedure:**
  - Cuttings samples collected every 30'
  - Total of 58 samples analyzed from 4480'-6160'
  - Sent to lab to run XRF analysis
    - Ran analysis 2 times per sample

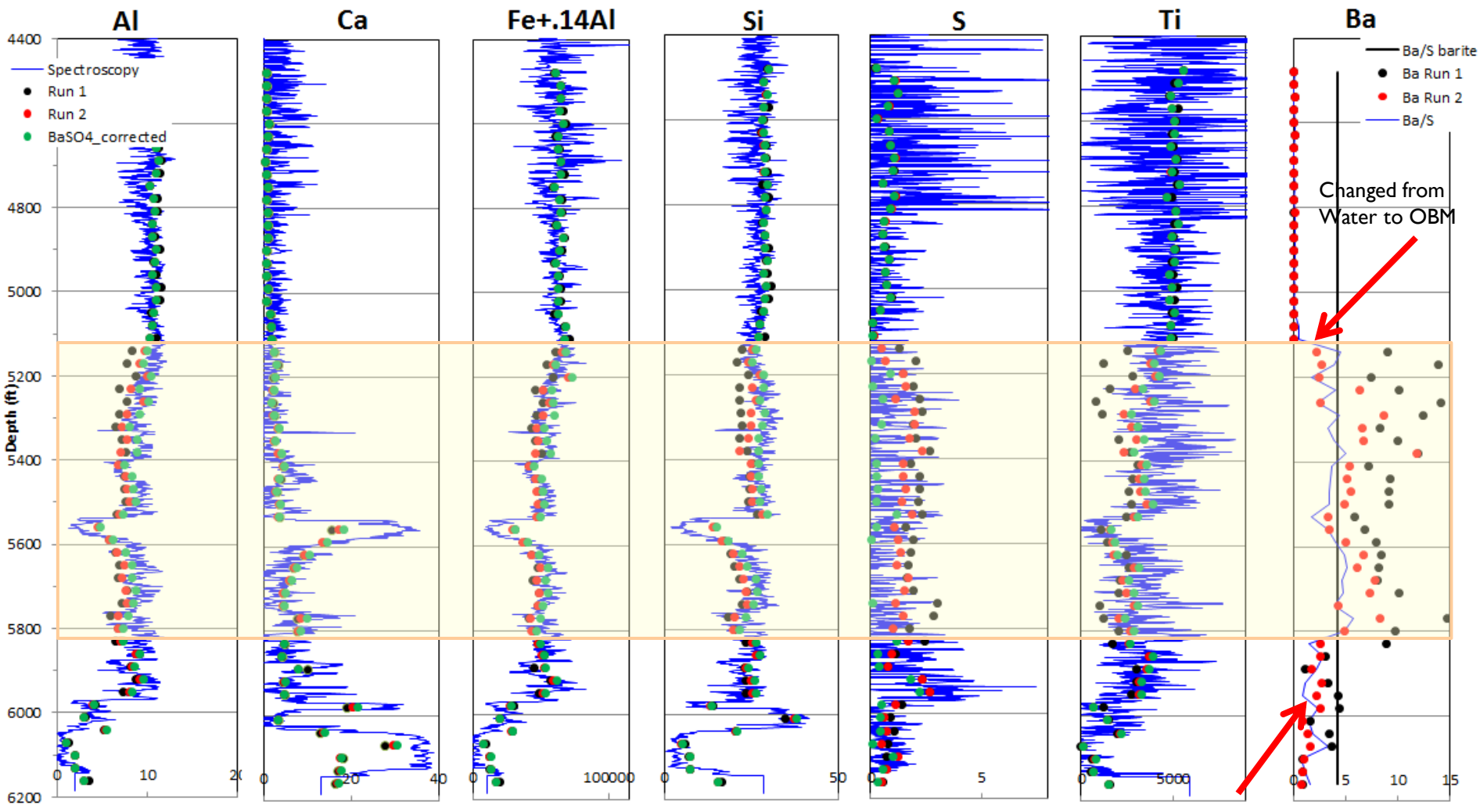


Marcellus Shale Extents

XRF: Aluminum Curve Comparison

- **Observations**:
  - Overall shape of Al curve matches fairly well
  - Log derived curve overestimate or underestimate in several places.
  - Bias is not always unidirectional
    - Consistent across all elements
  - High concentrations of Ba in the cuttings
  - $BaSO_4$ concentrations were examined to explain inconsistencies in the cuttings

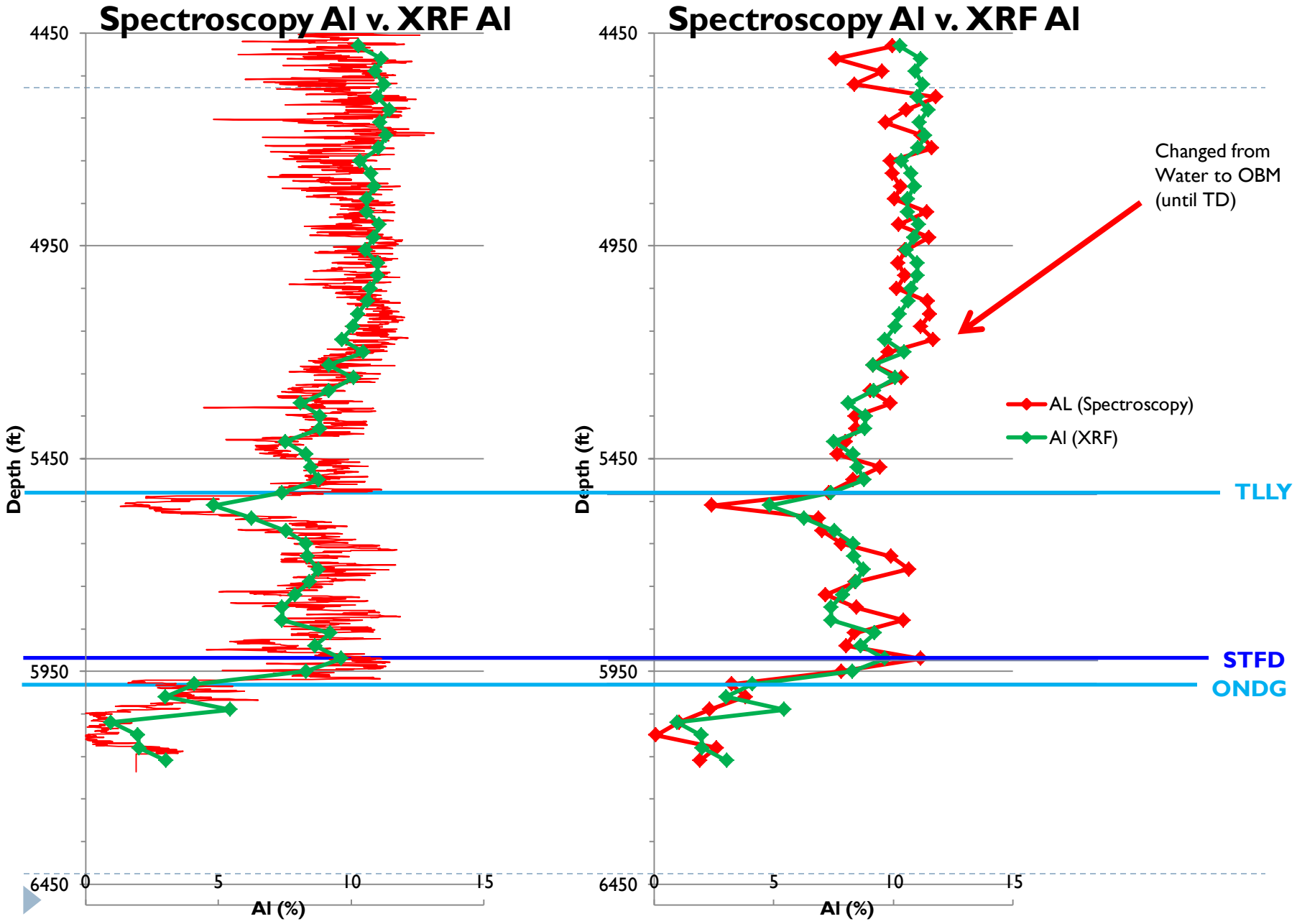
Quick look comparison of elemental capture spectroscopy elements



Still using OBM, however, decrease is likely due to increase in S concentrations

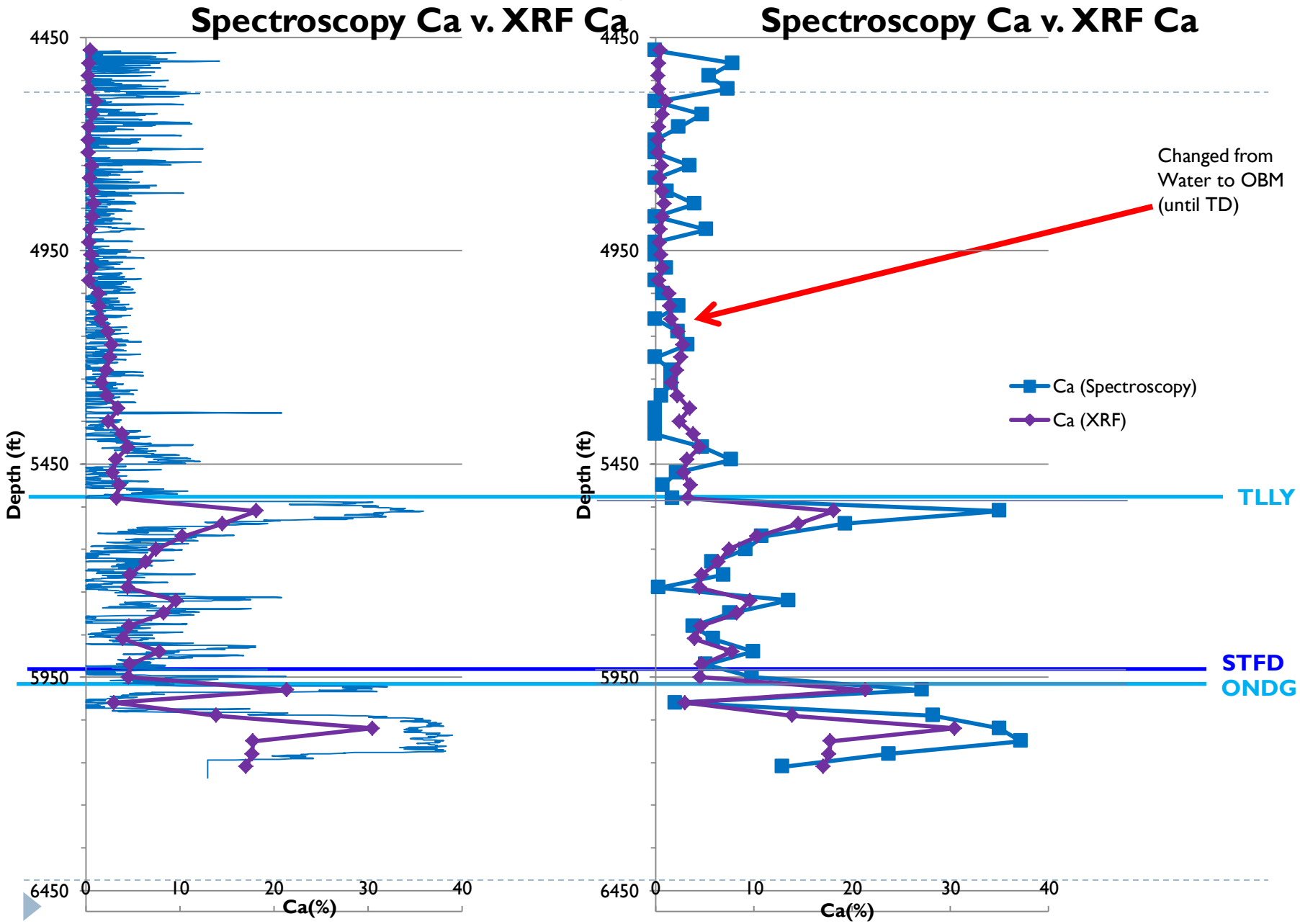
Aluminum

Elemental capture spectroscopy data and XRF data comparison



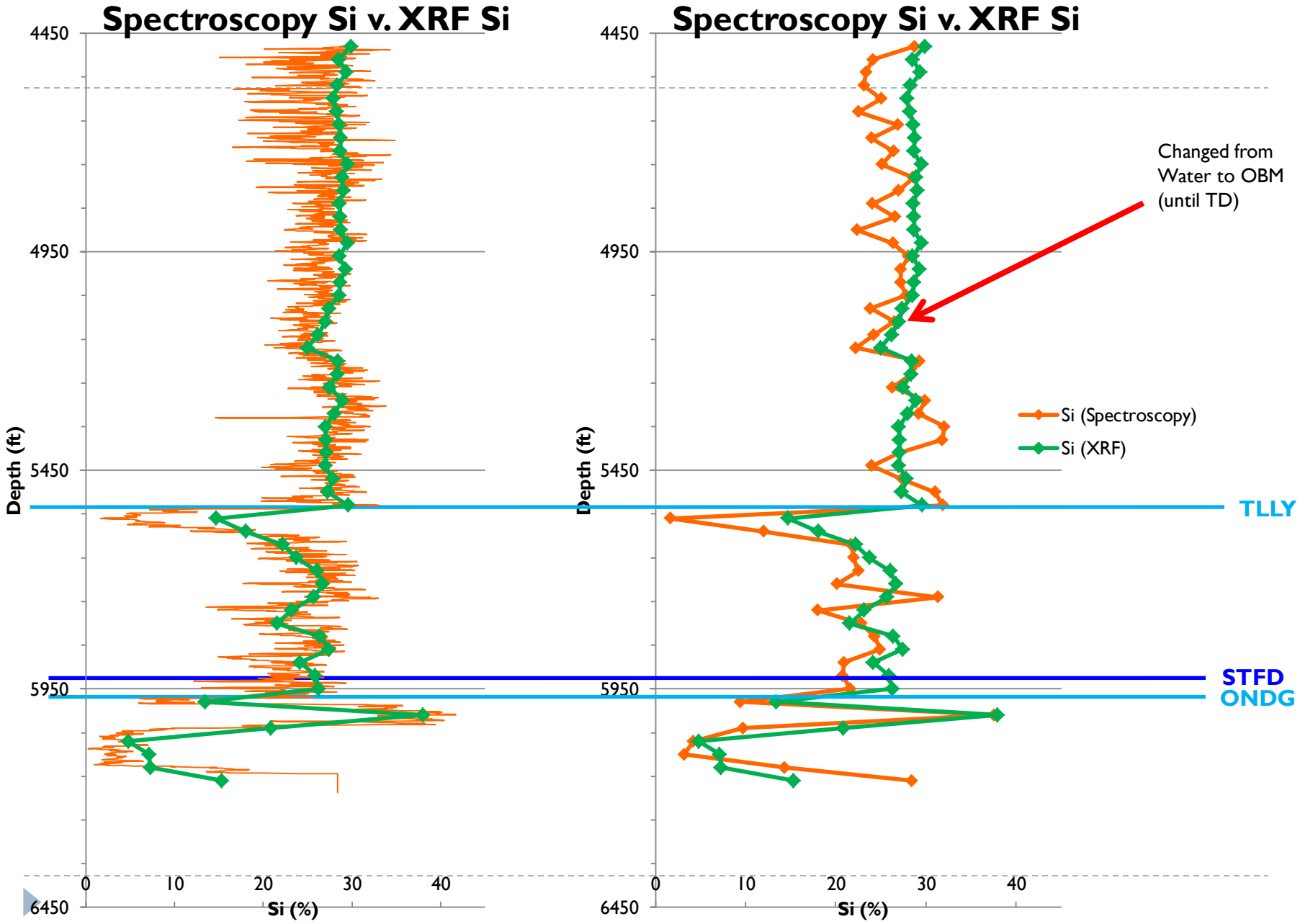
Calcium

Elemental capture spectroscopy data and XRF data comparison



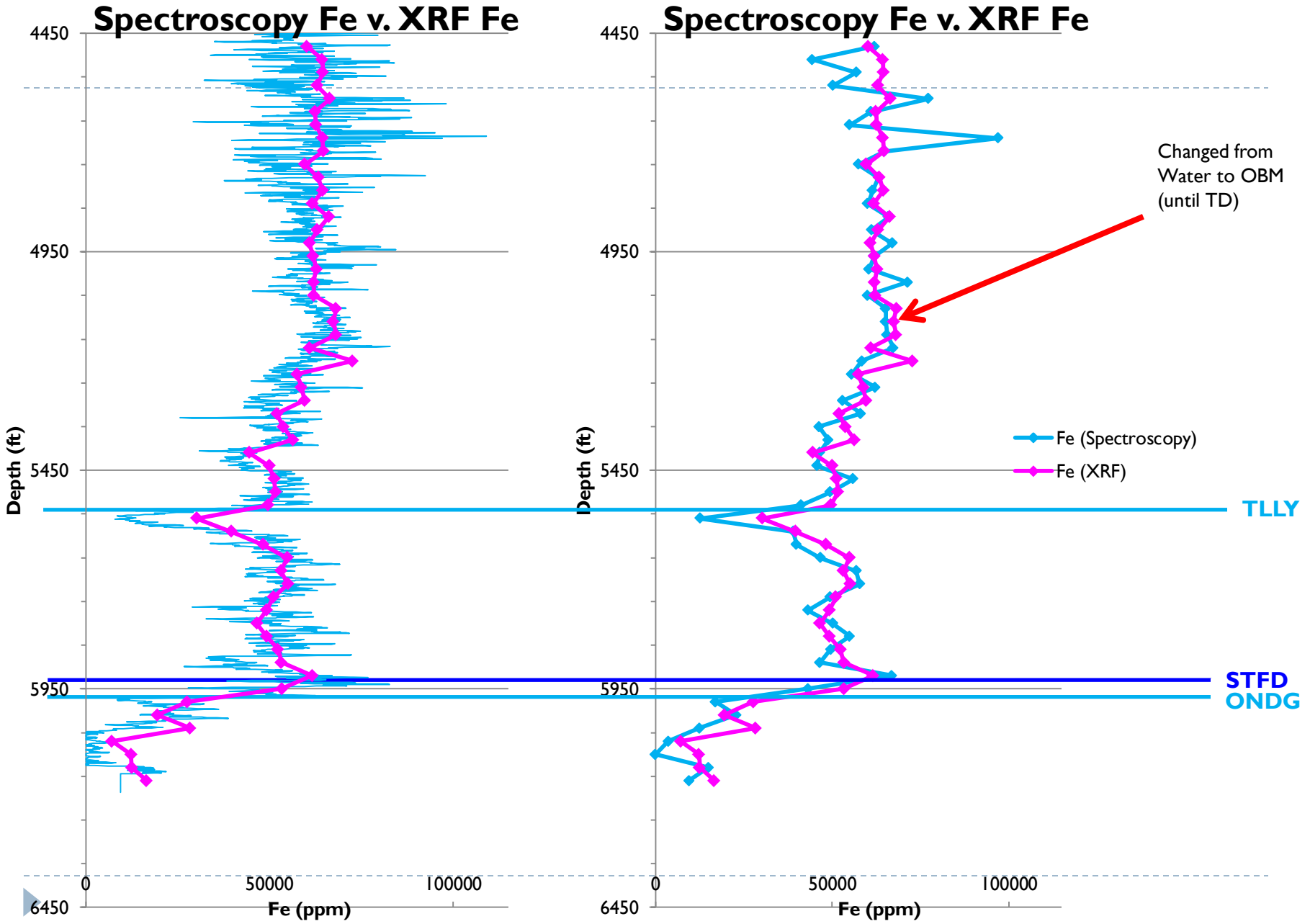
Silicon

Elemental capture spectroscopy data and XRF data comparison



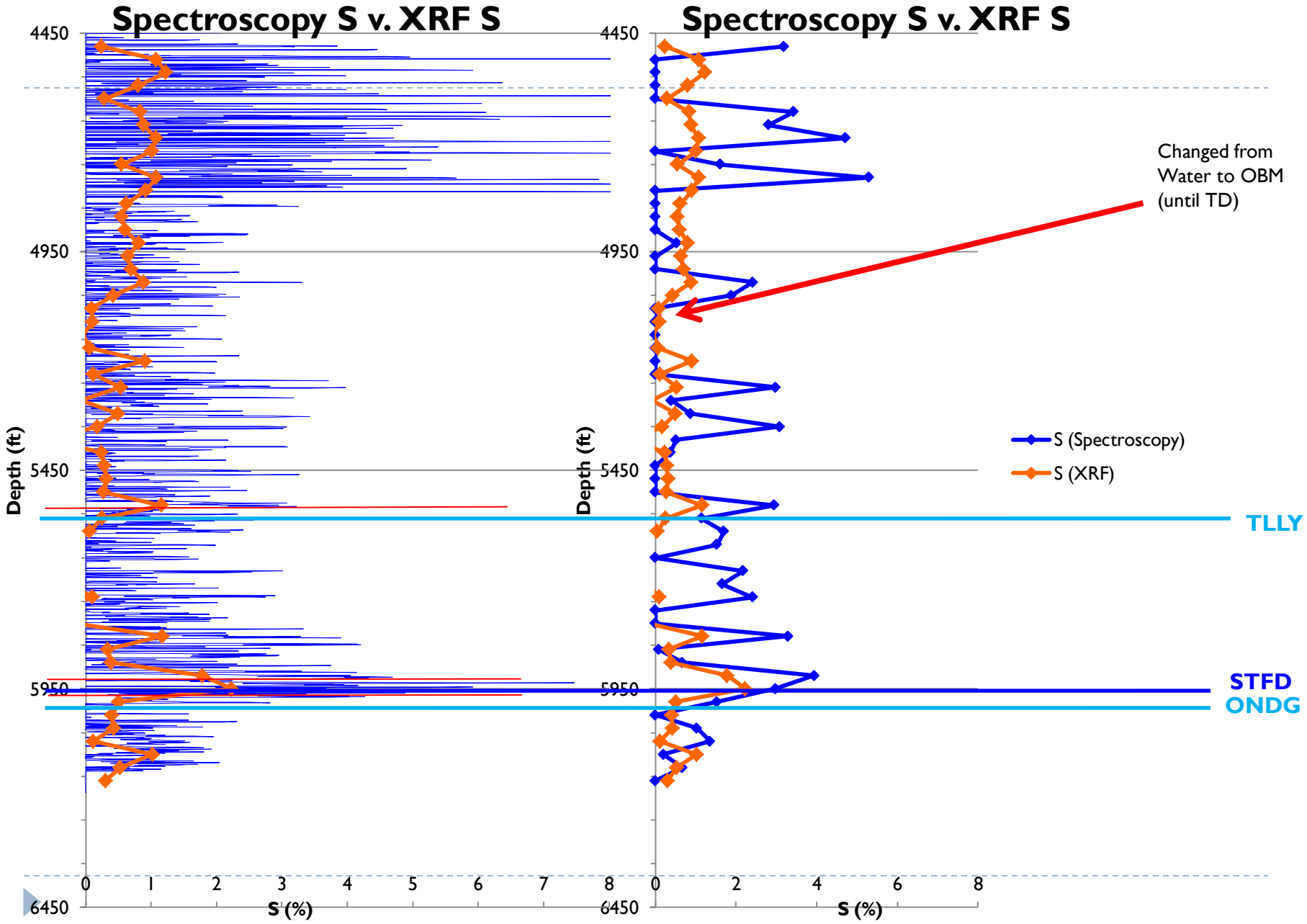
Iron

Elemental capture spectroscopy data and XRF data comparison



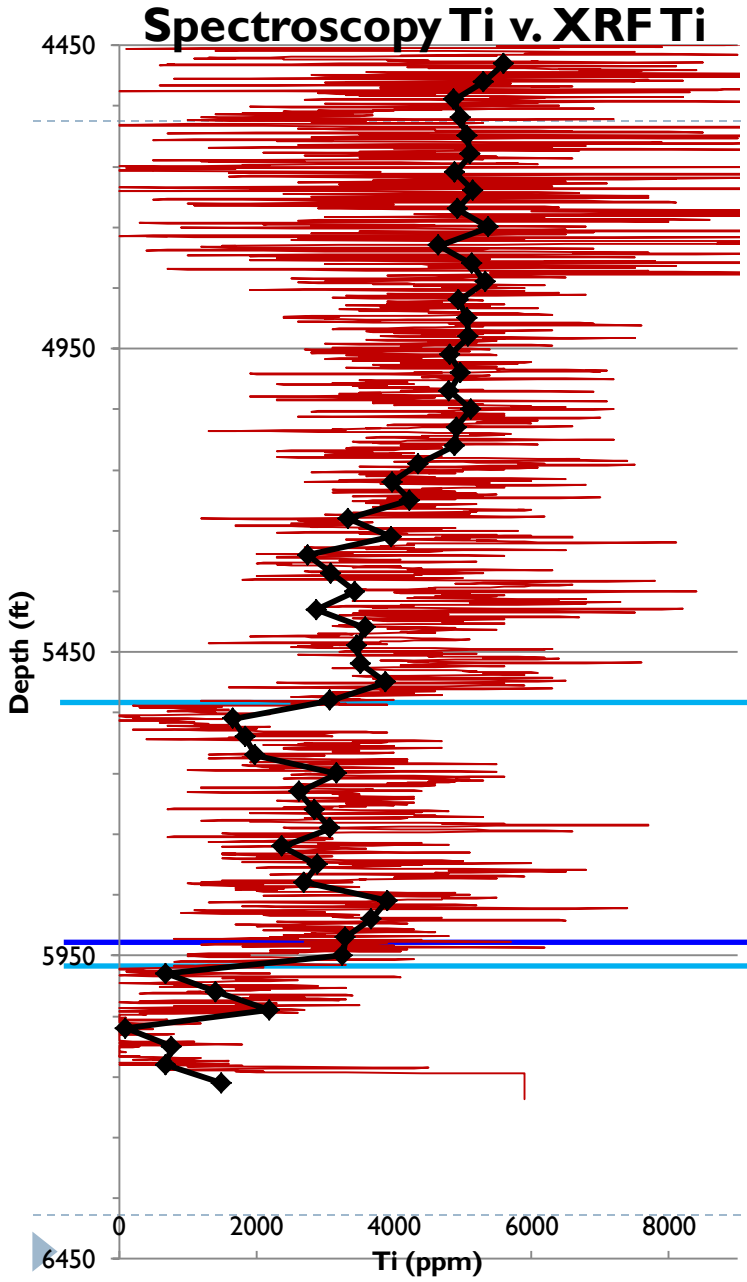
Sulfur

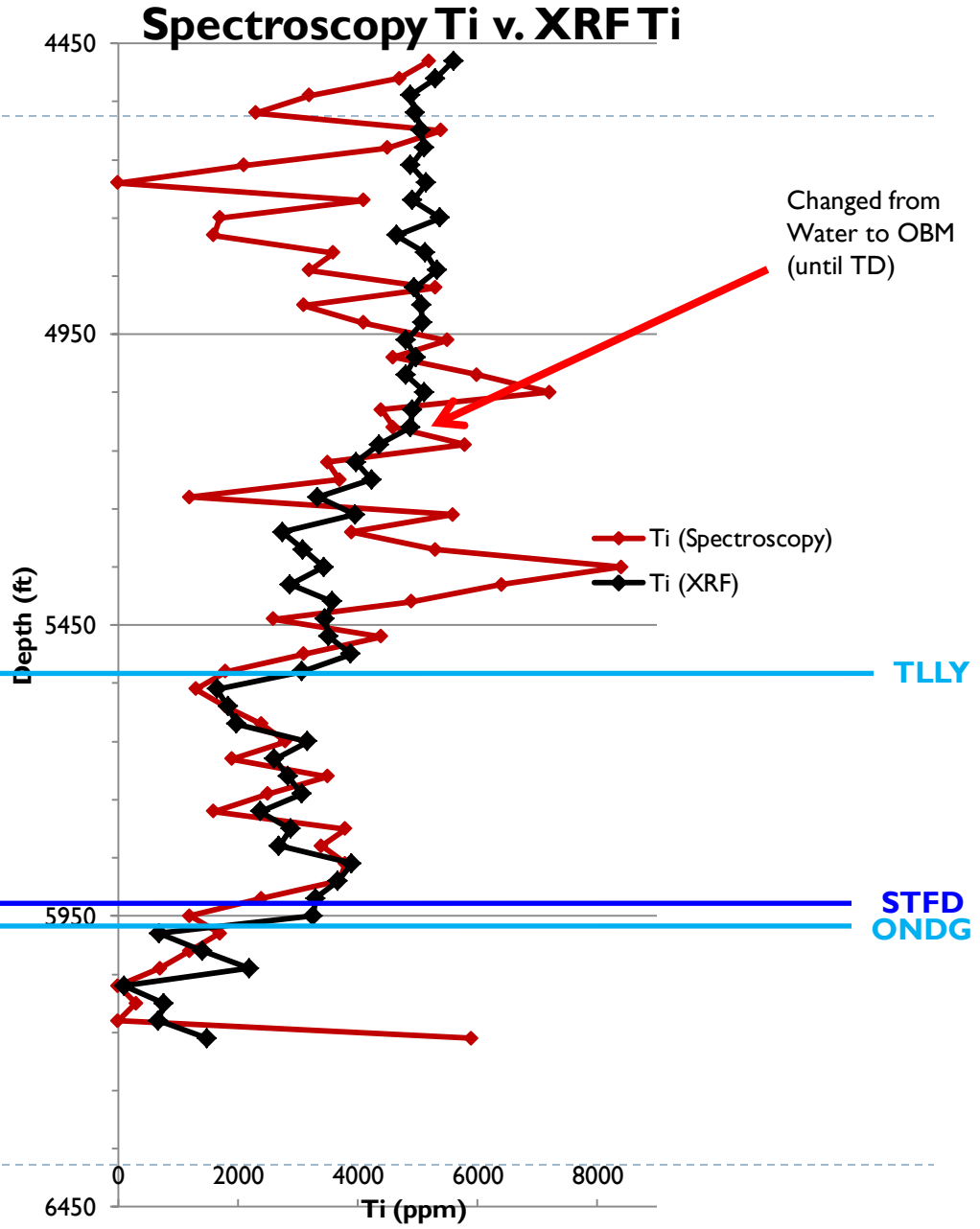
Elemental capture spectroscopy data and XRF data comparison



Titanium

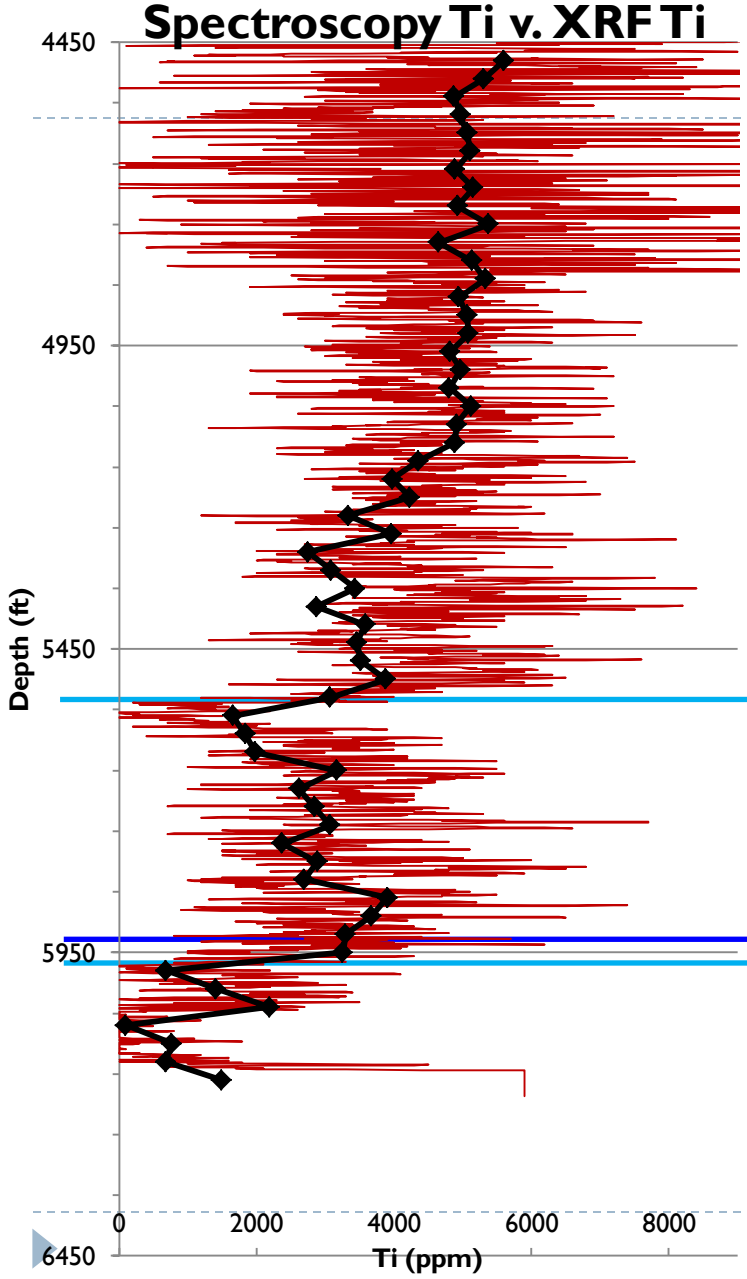
Elemental capture spectroscopy data and XRF data comparison

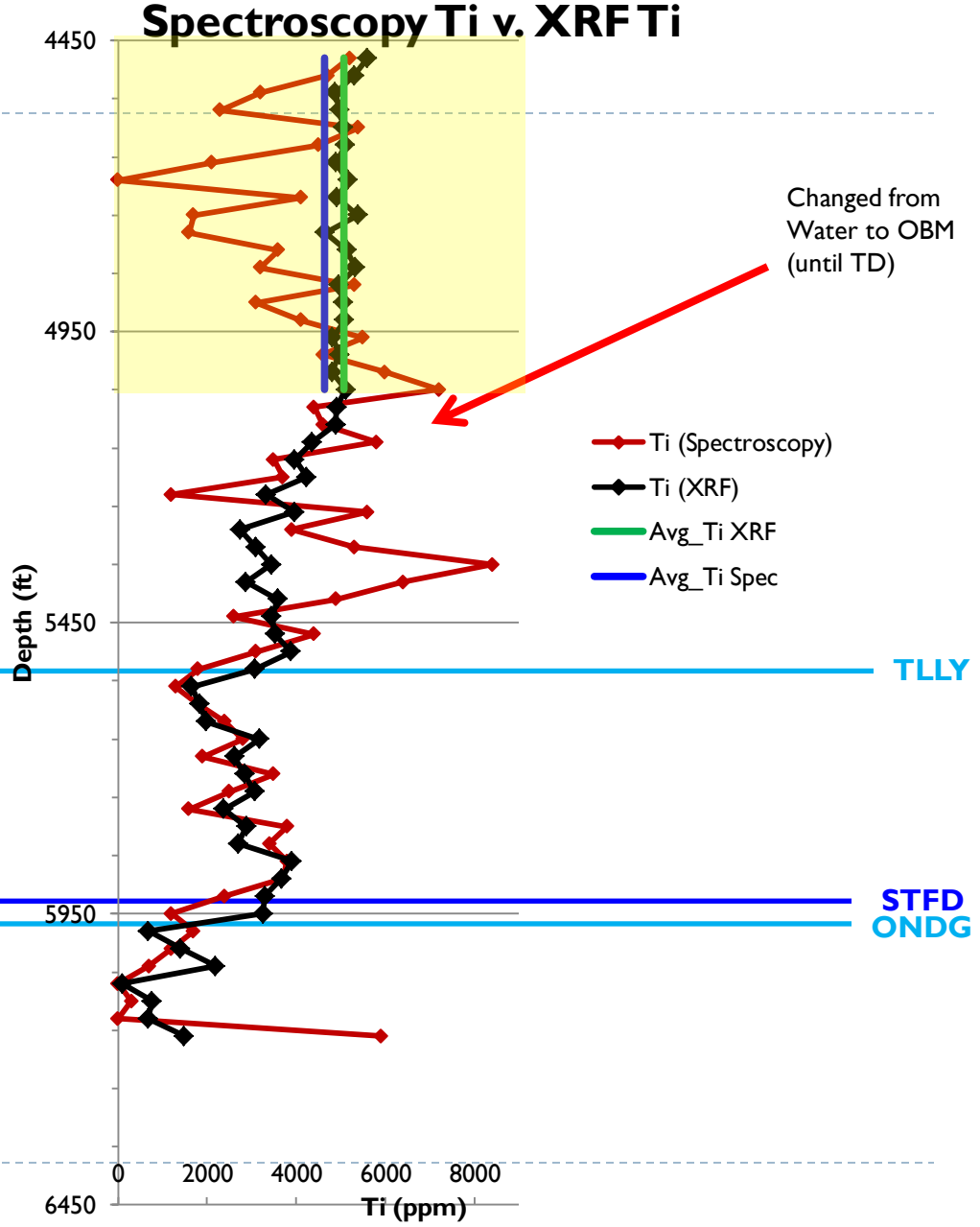




Titanium

Elemental capture spectroscopy data and XRF data comparison





Conclusions

- Derived Al concentrations from the spectroscopy logs is generally representative of measured Al concentrations
- This is true for the other main elemental concentrations.
- $BaSO_4$ contamination from drilling mud caused erroneous readings from the XRF data.
- Once corrected for, the XRF data matched the spectroscopy data fairly well
- Gives greater confidence in using existing data in future analyses of the shale.