Adrienne Bryant, M.S. Candidate, May 2022

CHARACTERIZATION OF THE GRANEROS SHALE: A KEY SOURCE ROCK OF THE DENVER BASIN

Outline

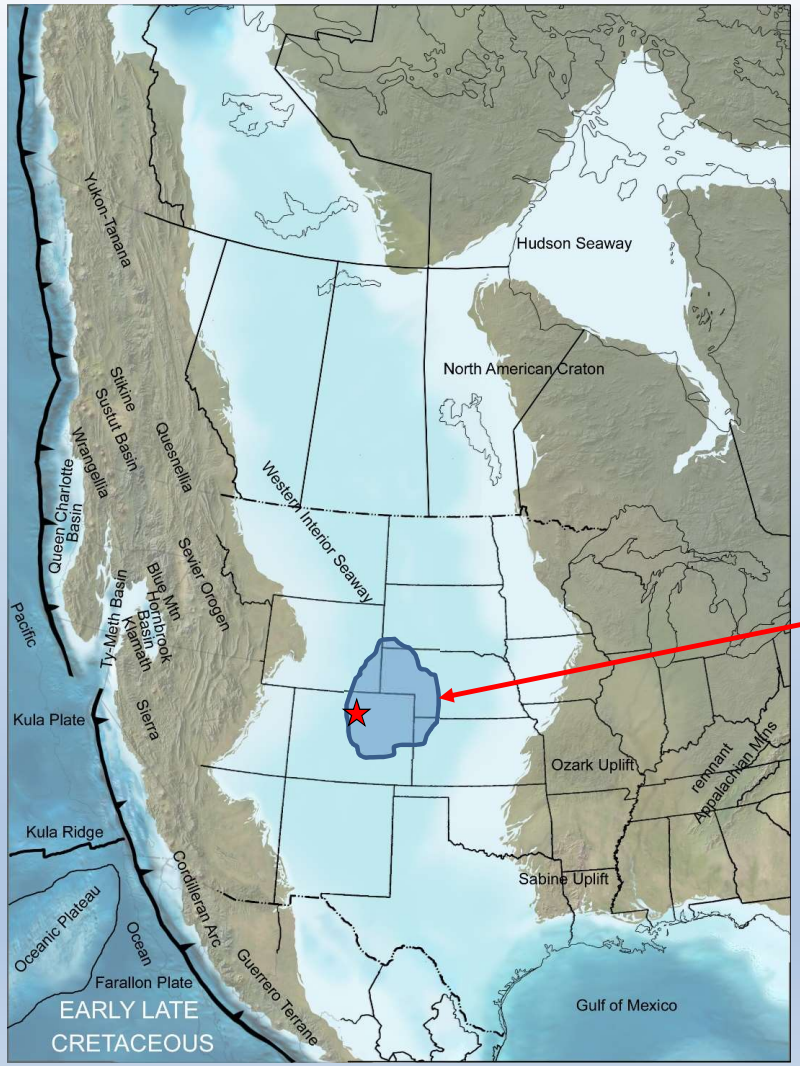
- Objective
- Geologic Setting
- Stratigraphic Setting
- Petroleum System
- Cores
- Core locations
- Fractures in the Graneros
- For each core
  - Overview
  - Detrital Indicators
  - Redox Sensitive Trace Elements
  - Organophillic Trace Elements
  - Euxinia Proxies
- Future Work

Objective

- To characterize the Graneros Shale in Wattenberg Field of the Denver-Julesburg Basin.

Significance:

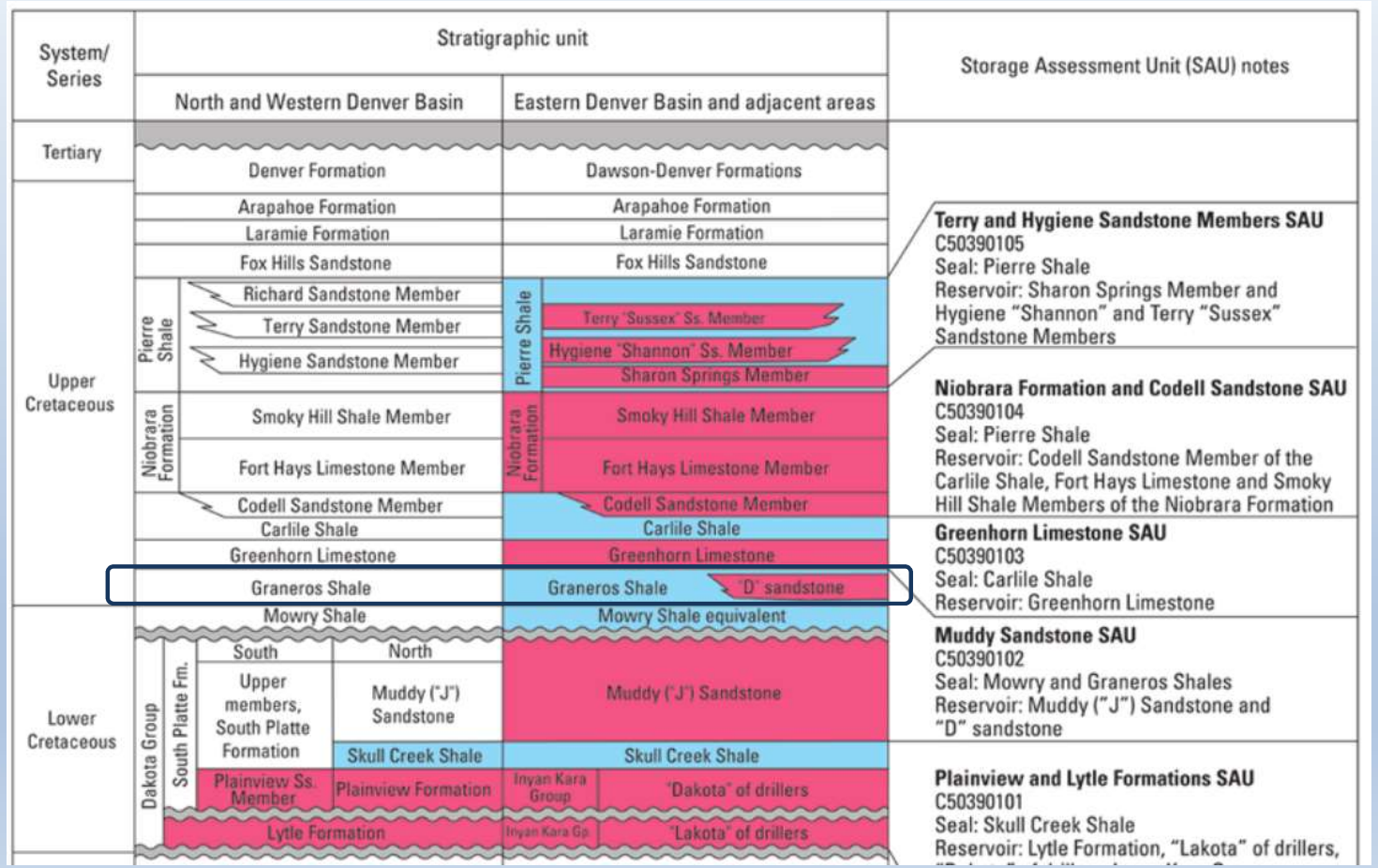
- The Graneros is a key source rock of the DJ Basin.
- Elemental data provides insight on anoxia conditions, sediment input, and more.
- Understand the source potential and if any areas of the Graneros could be a target.



Approximate location of the DJ Basin

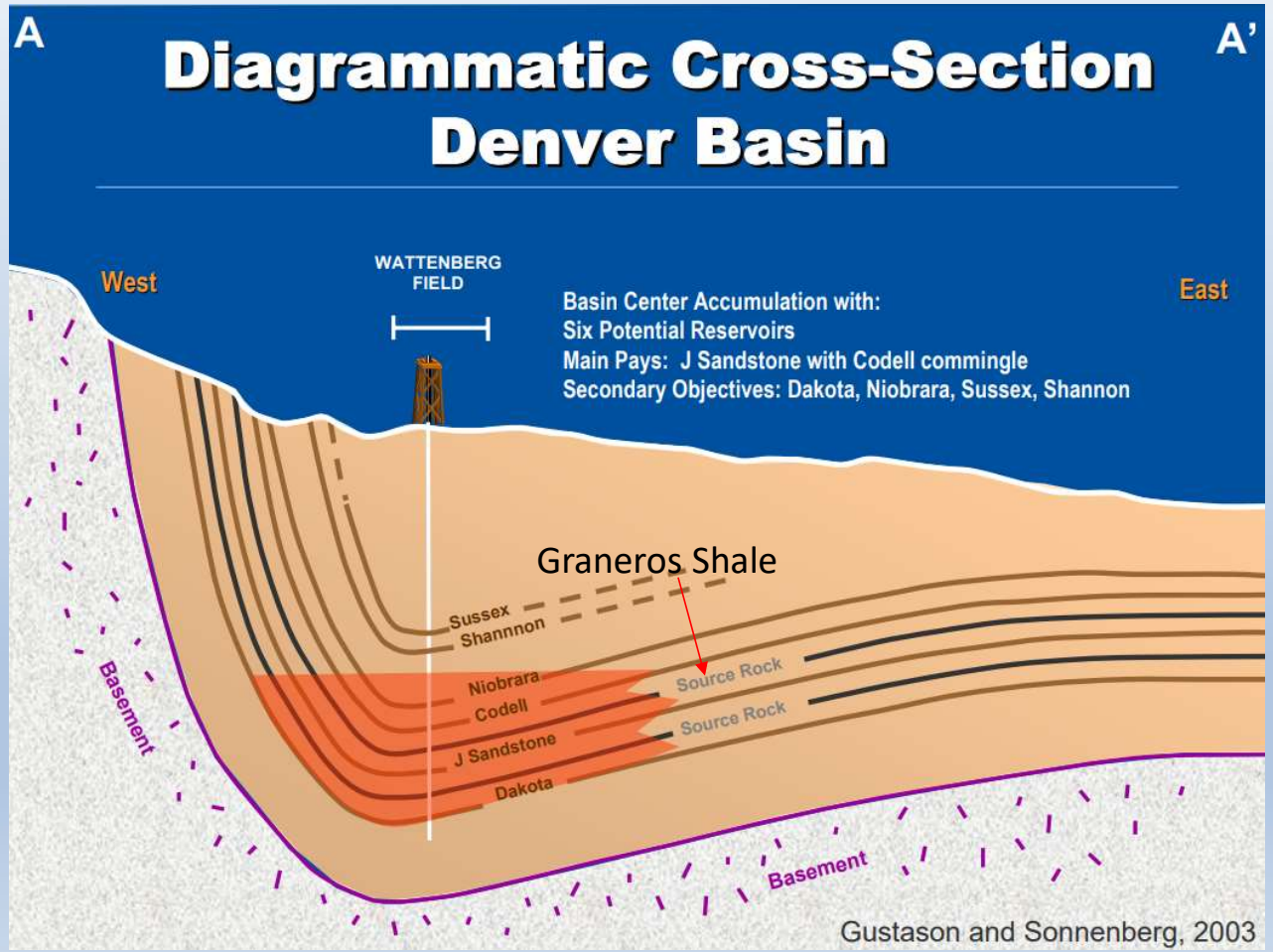
Blakey

Stratigraphic Setting



Drake et al, 2014; modified from Higley and Cox, 2007

Petroleum System



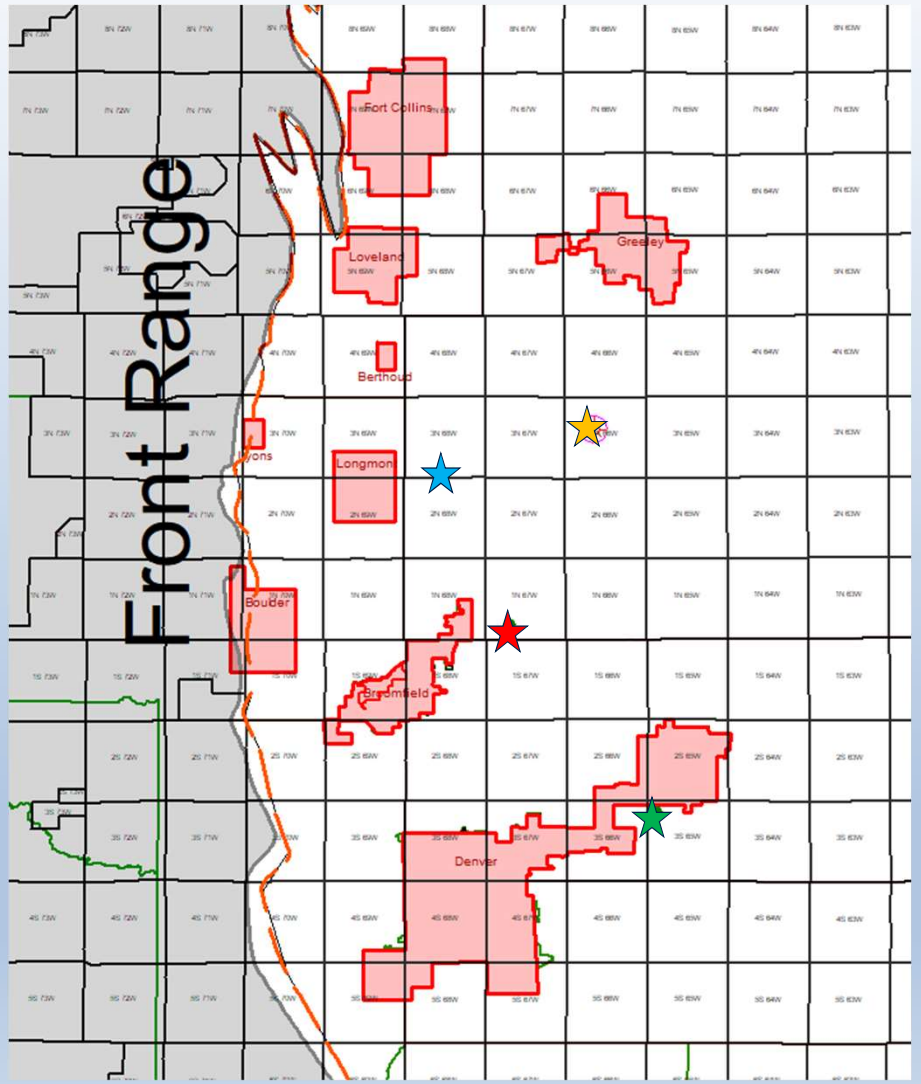
Cores

- Coland State 5-16, SWNW sec 16-3N-66W, Weld Co., CO
- Adler 16-33, SESE sec 33-3N-68W, Weld Co. CO
- Howard 16-29, SESE sec 29-1N-67W, Weld Co., CO
- Box Elder Farms 6-32 ; SWSE sec-3S-65W, Adams Co., CO

Well Locations

Wattenberg Field

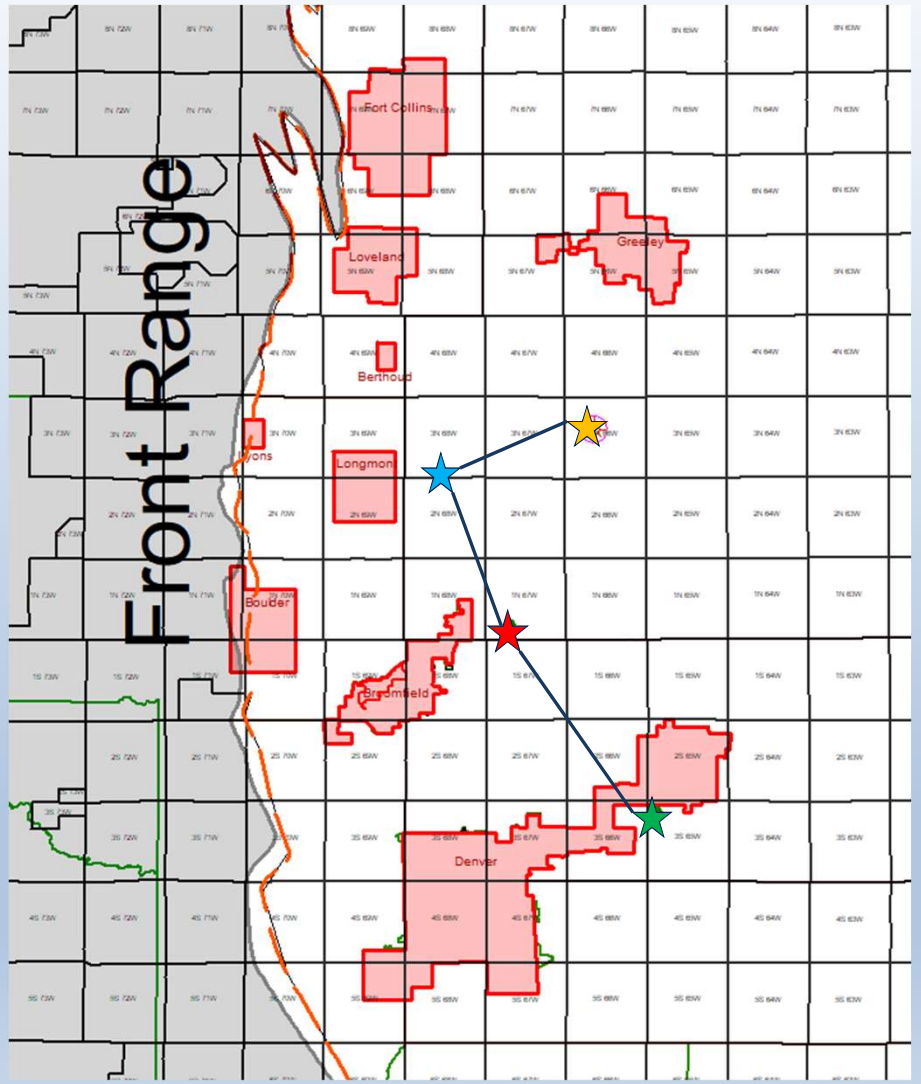
- Coland State 5-16
- Adler 16-33
- Howard 16-29
- Box Elder Farms 6-32

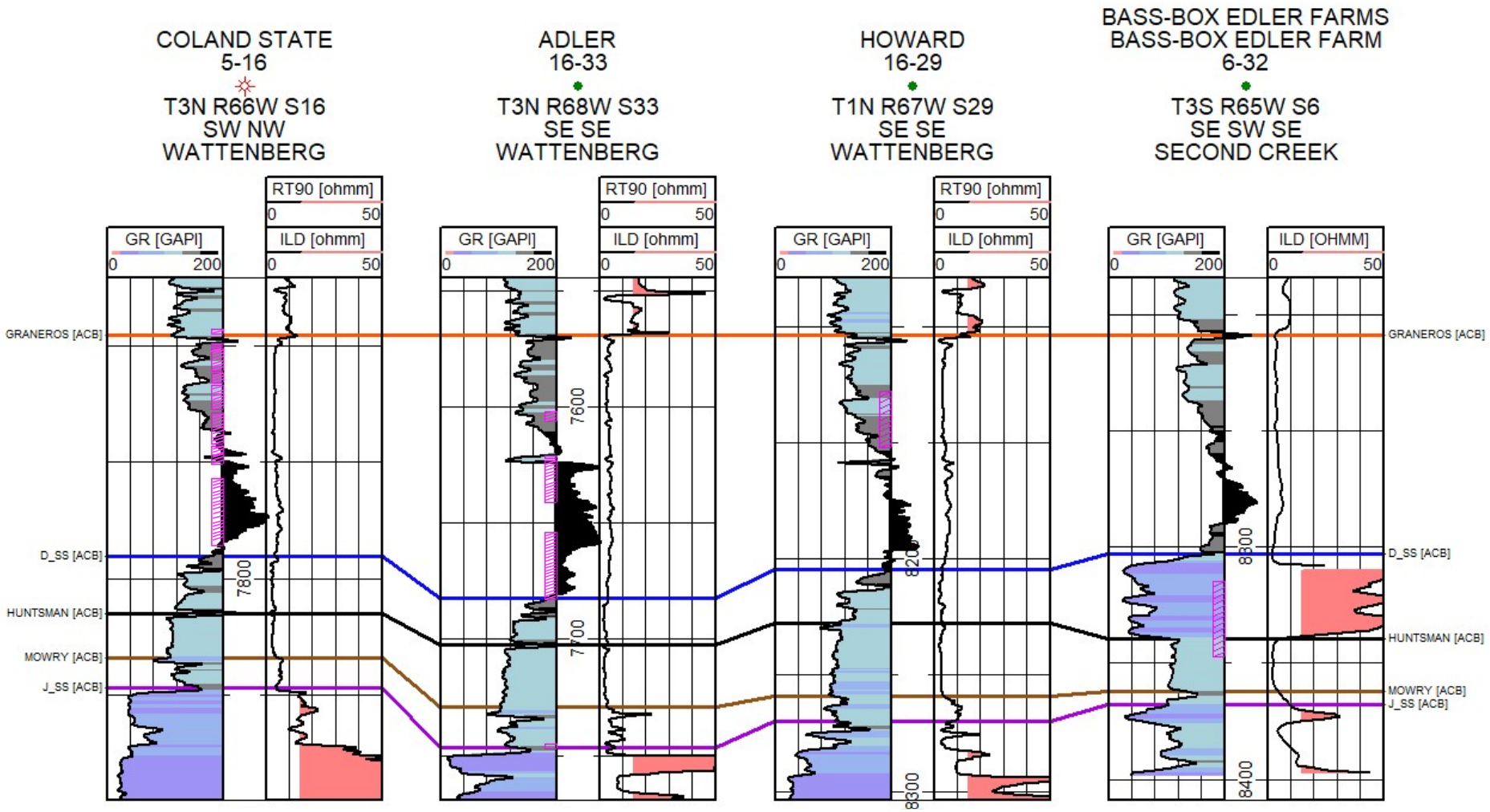


Well Locations

Wattenberg Field

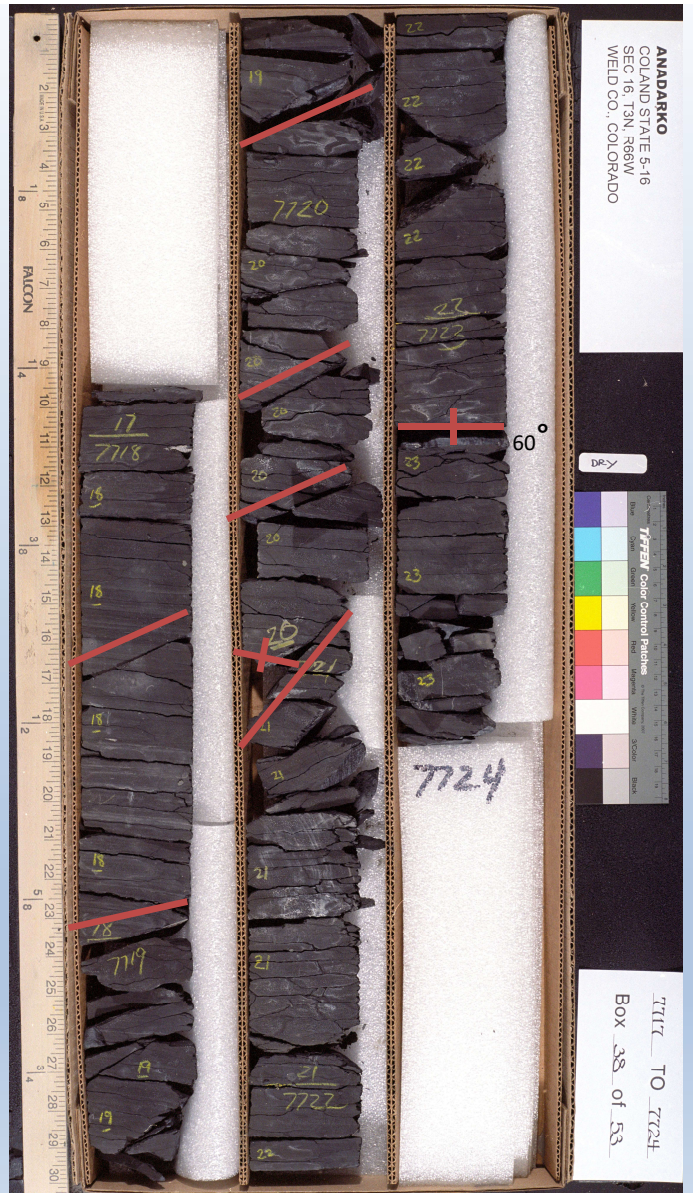
- Coland State 5-16
- Adler 16-33
- Howard 16-29
- Box Elder Farms 6-32



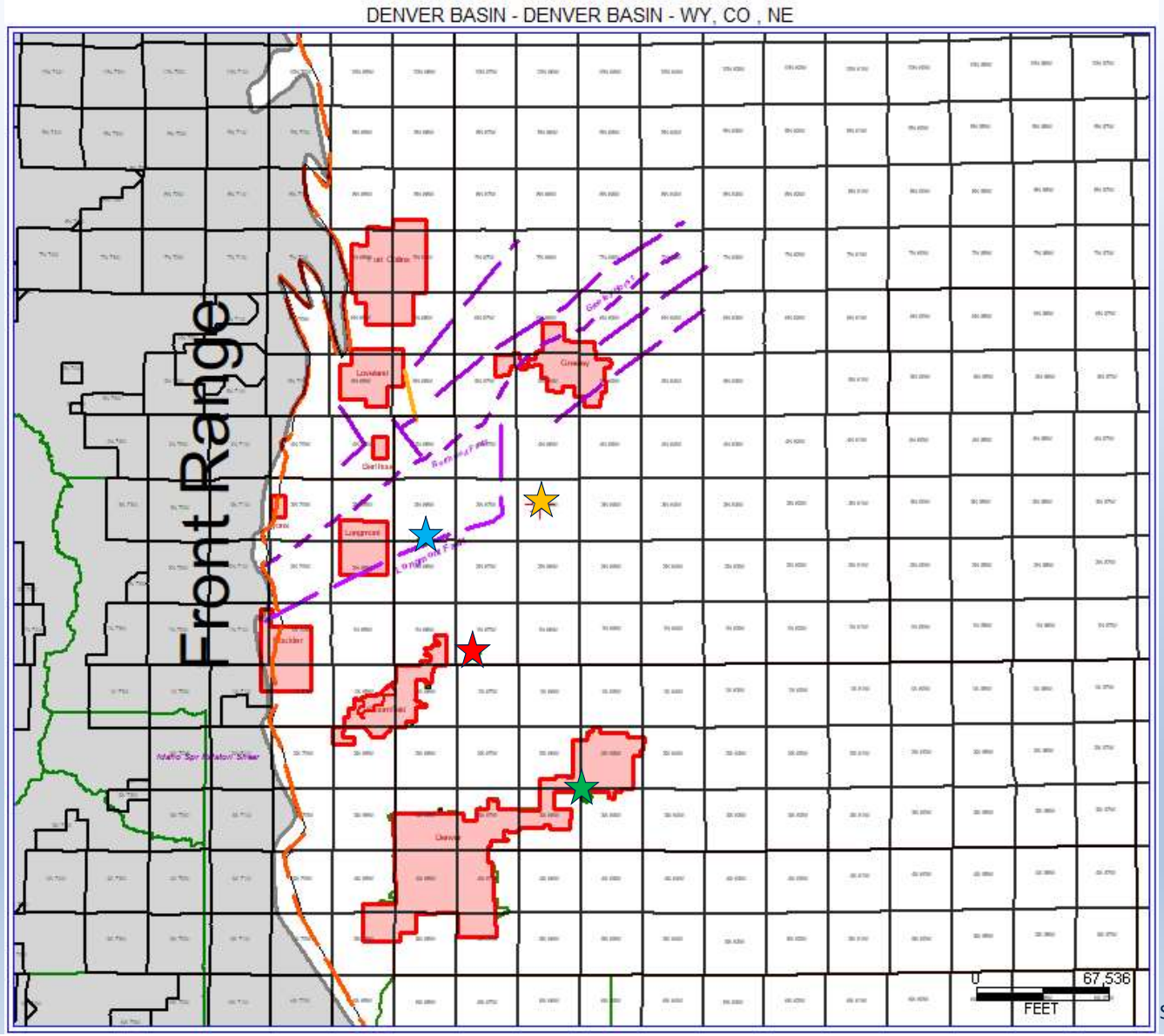

COLAND STATE
5-16
T3N R66W S16
SW NW
WATTENBERG
ADLER
16-33
T3N R68W S33
SE SE
WATTENBERG
HOWARD
16-29
T1N R67W S29
SE SE
WATTENBERG
BASS-BOX EDLER FARMS
BASS-BOX EDLER FARM
6-32
T3S R65W S6
SE SW SE
SECOND CREEK
RT90 [ohmm]
0 50
GR [GAPI]
0 200
ILD [ohmm]
ILD [OHMM]
GRANEROS [ACB]
D_SS [ACB]
HUNTSMAN [ACB]
MOWRY [ACB]
J_SS [ACB]
7600
7800
7700
8200
8300
8300
8400

Fractures in the Core

- Fracture surfaces were observed in the cores.
  - Polished, slickenlines.
- Two dominant groups: horizonal dip and 30-45 degrees dip.
- 55 surfaces recorded in the Coland State core.
  - Vertical, calcite filled fracture.
- 4 surfaces recorded in the Adler core.
  - One vertical, calcite filled fracture.
- 1 surface in the Howard core.



Coland State

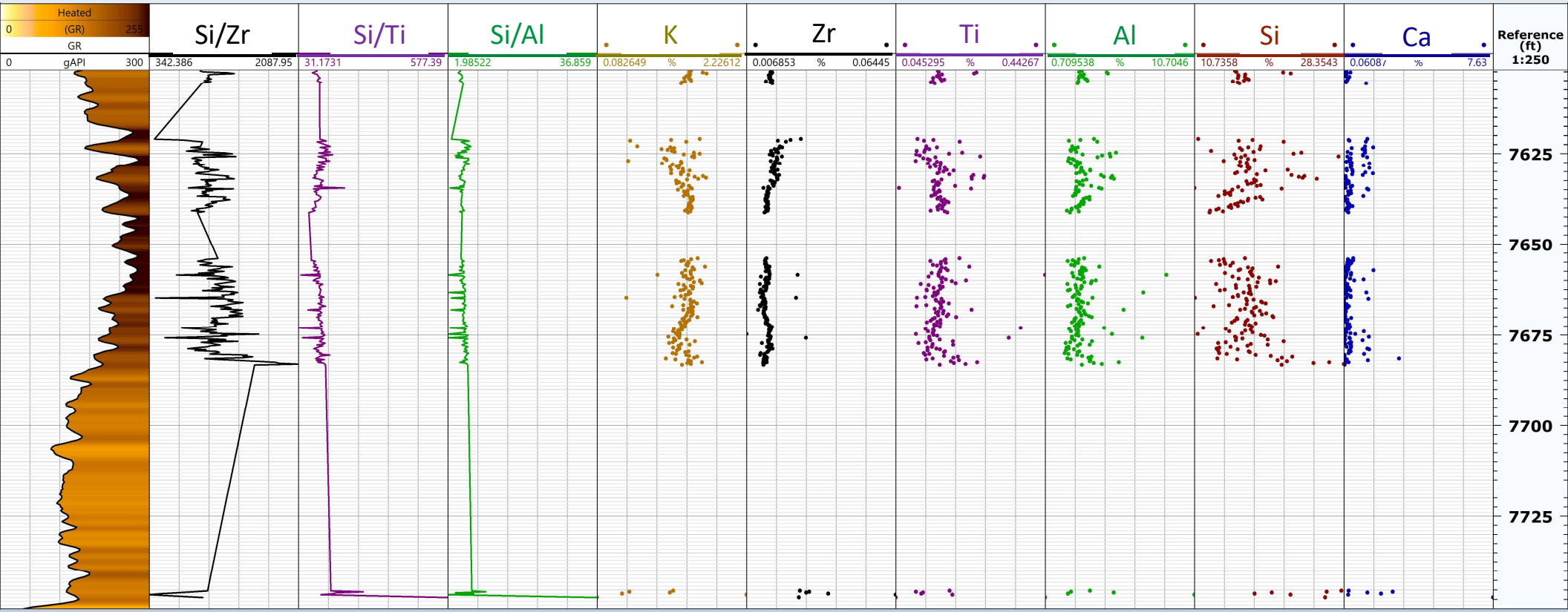


Sonnenberg

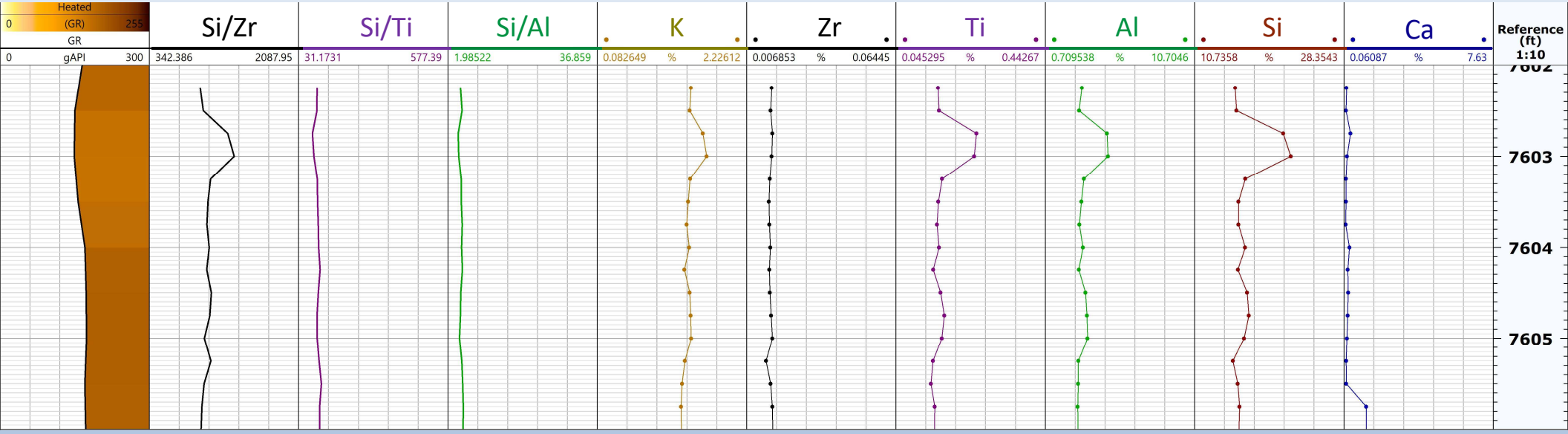
Core Overview – Adler

- Core did not contain the X-bentonite.
- Foraminifera sand at top of core.
- Trace fossils:
  - Inoceramid shells.
  - Ammonites
- Fish scales and bones.
- 10 ash layers in the core.
  - Grey to green to brownish.
- Pyrite nodules, disseminated.

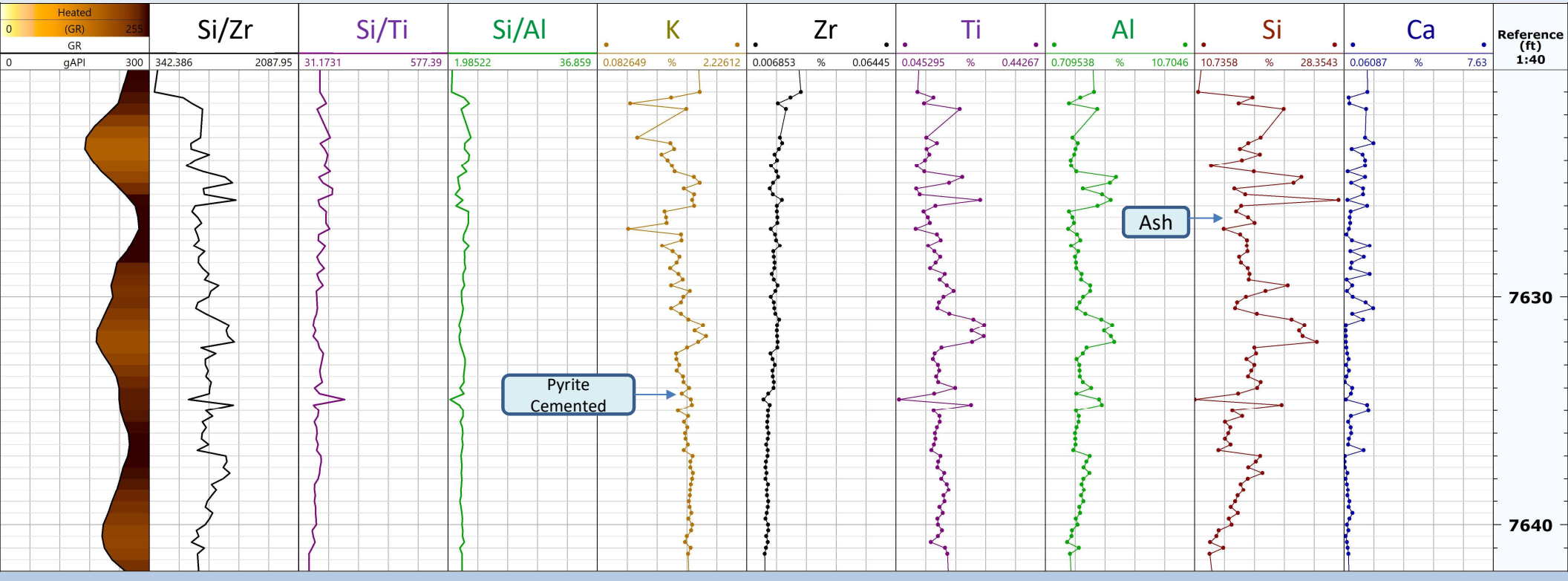
Adler – Detrital Indicators



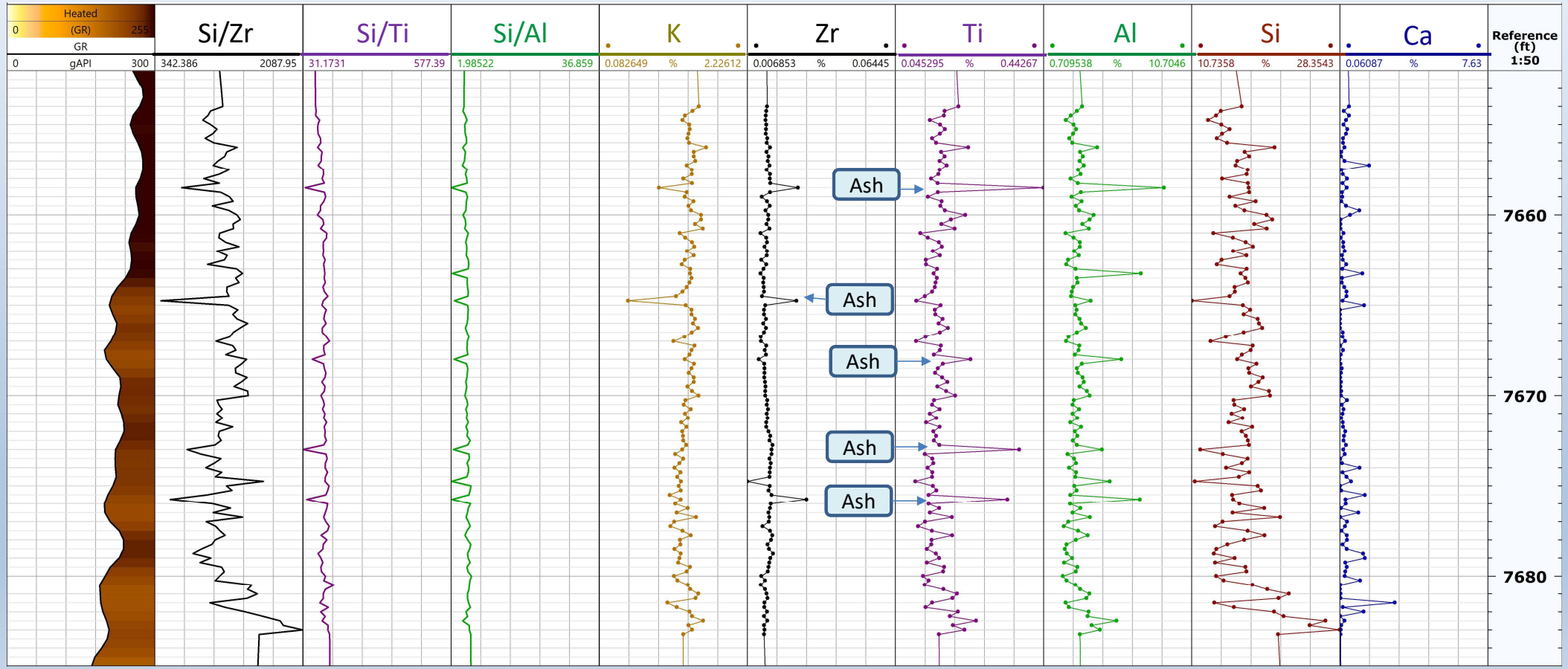
Adler – Detrital Indicators



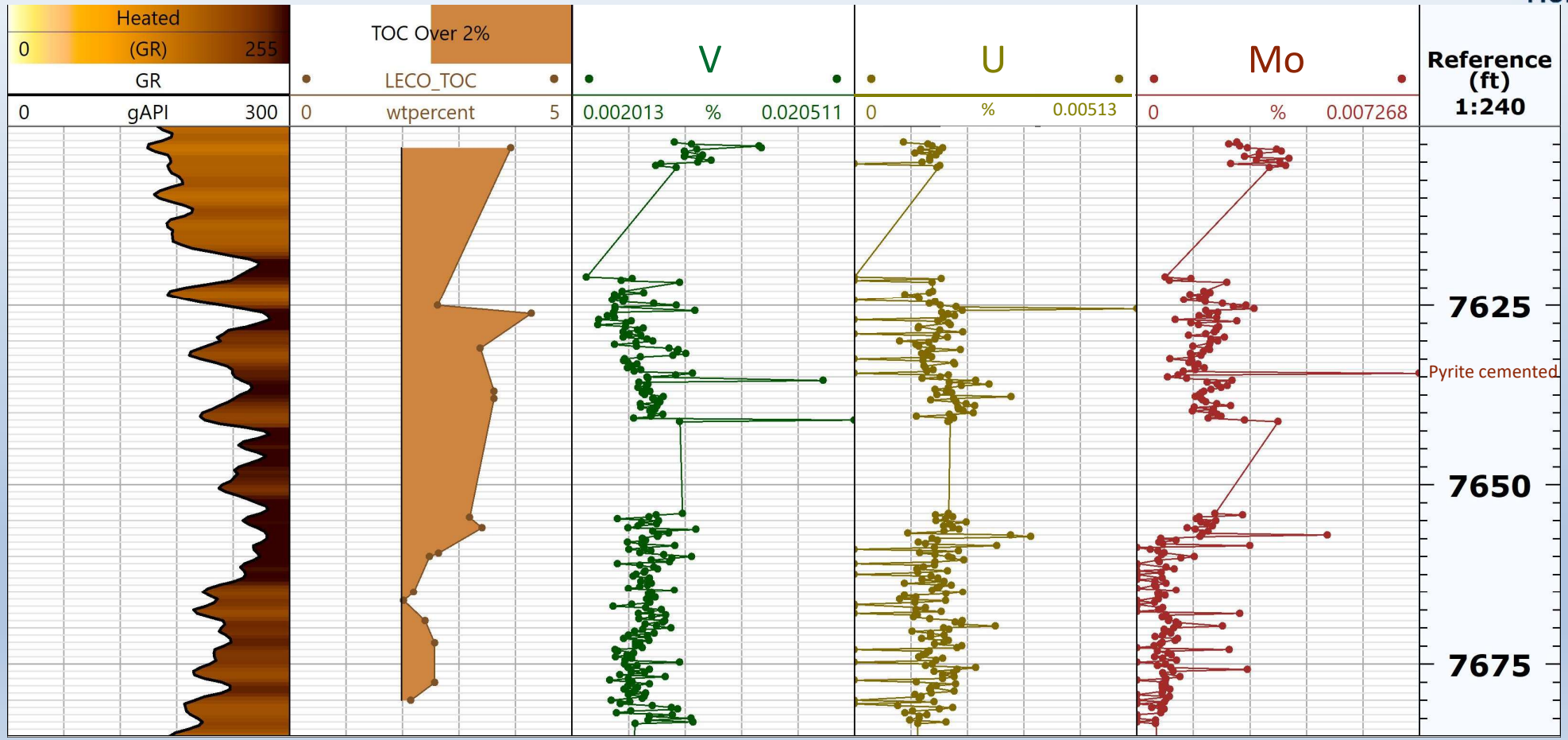
Adler – Detrital Indicators



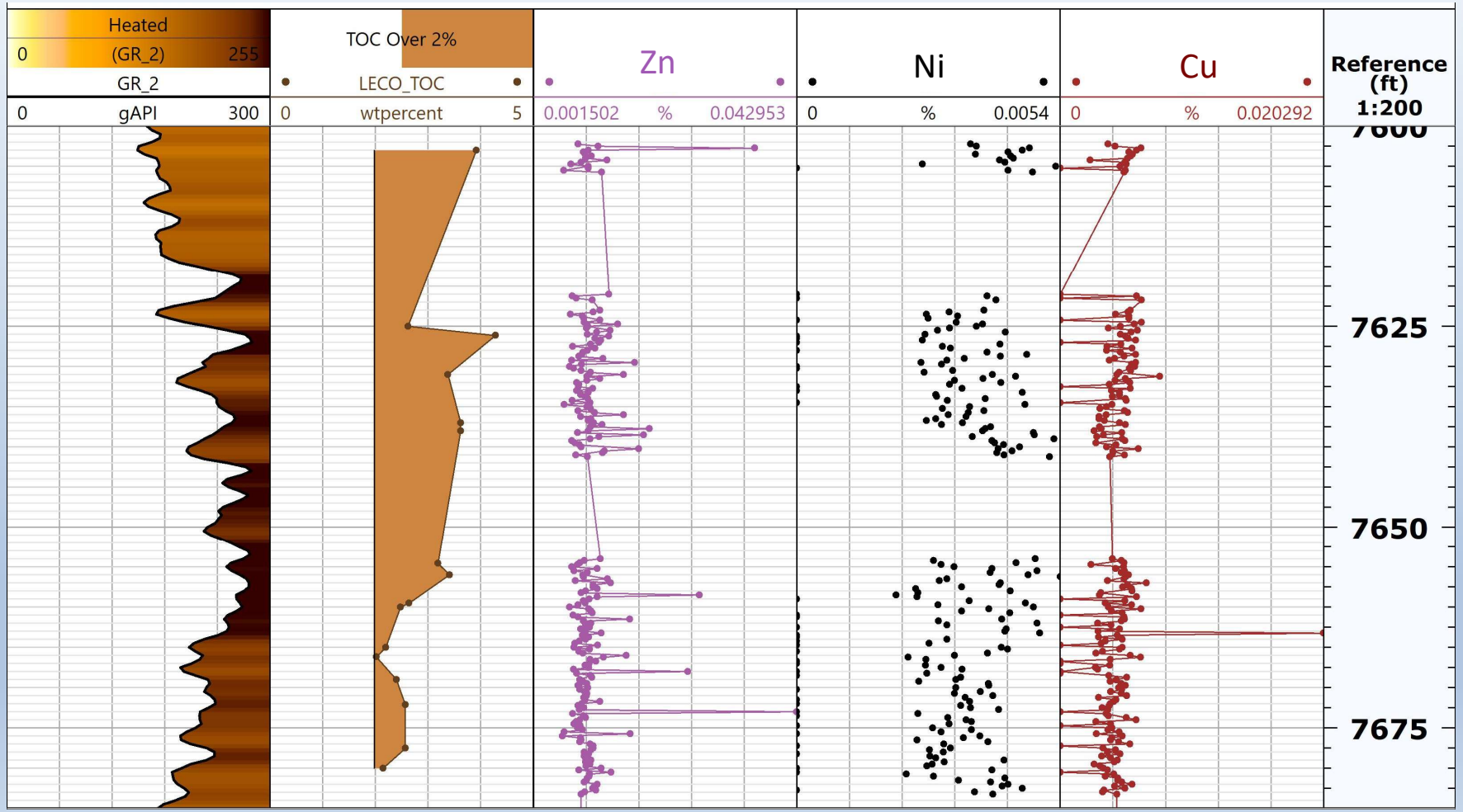
Adler – Detrital Indicators



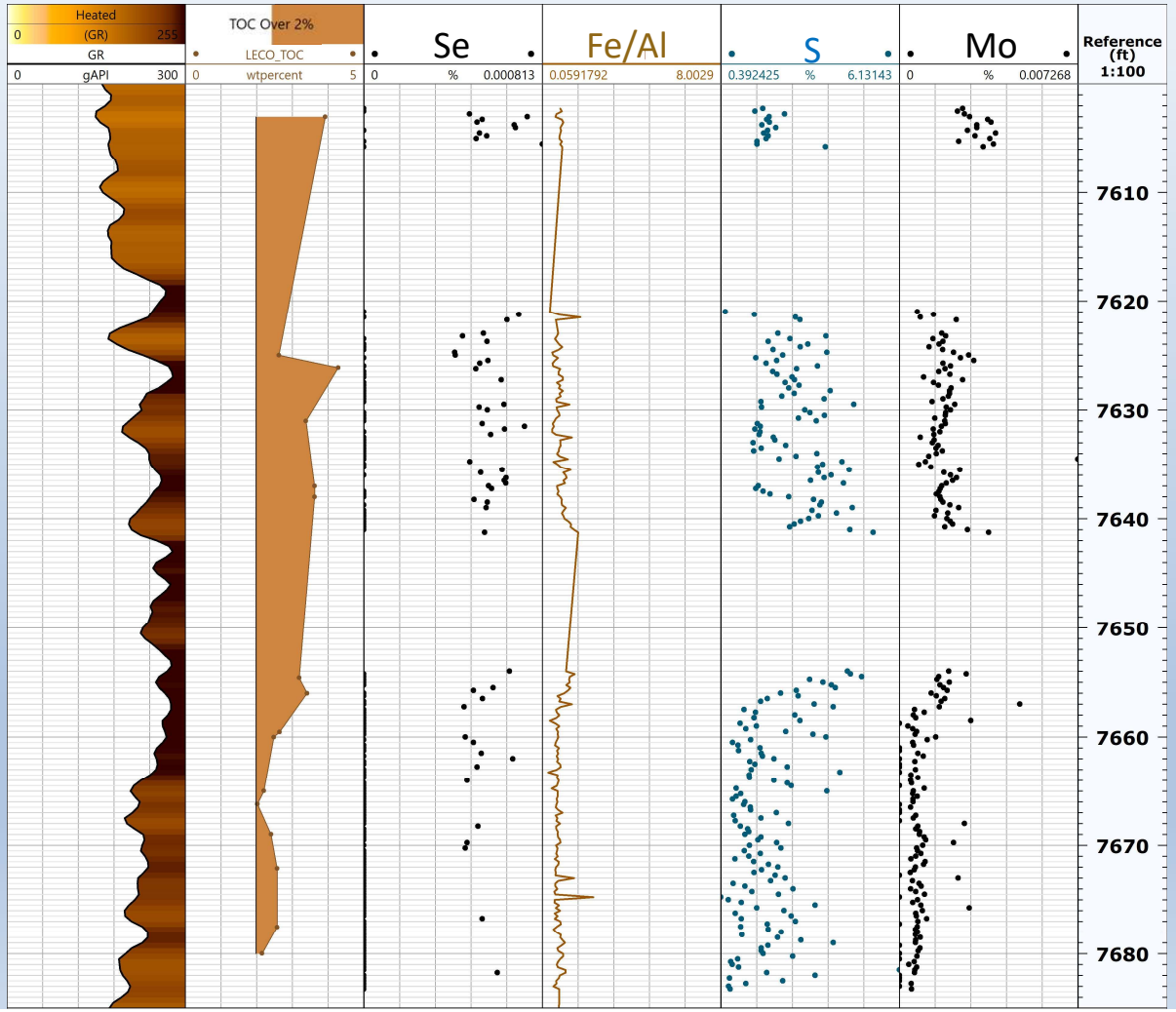
Adler – Redox Sensitive Trace Elements



Adler – Organophillic Trace Elements



Adler – Euxinia Proxies



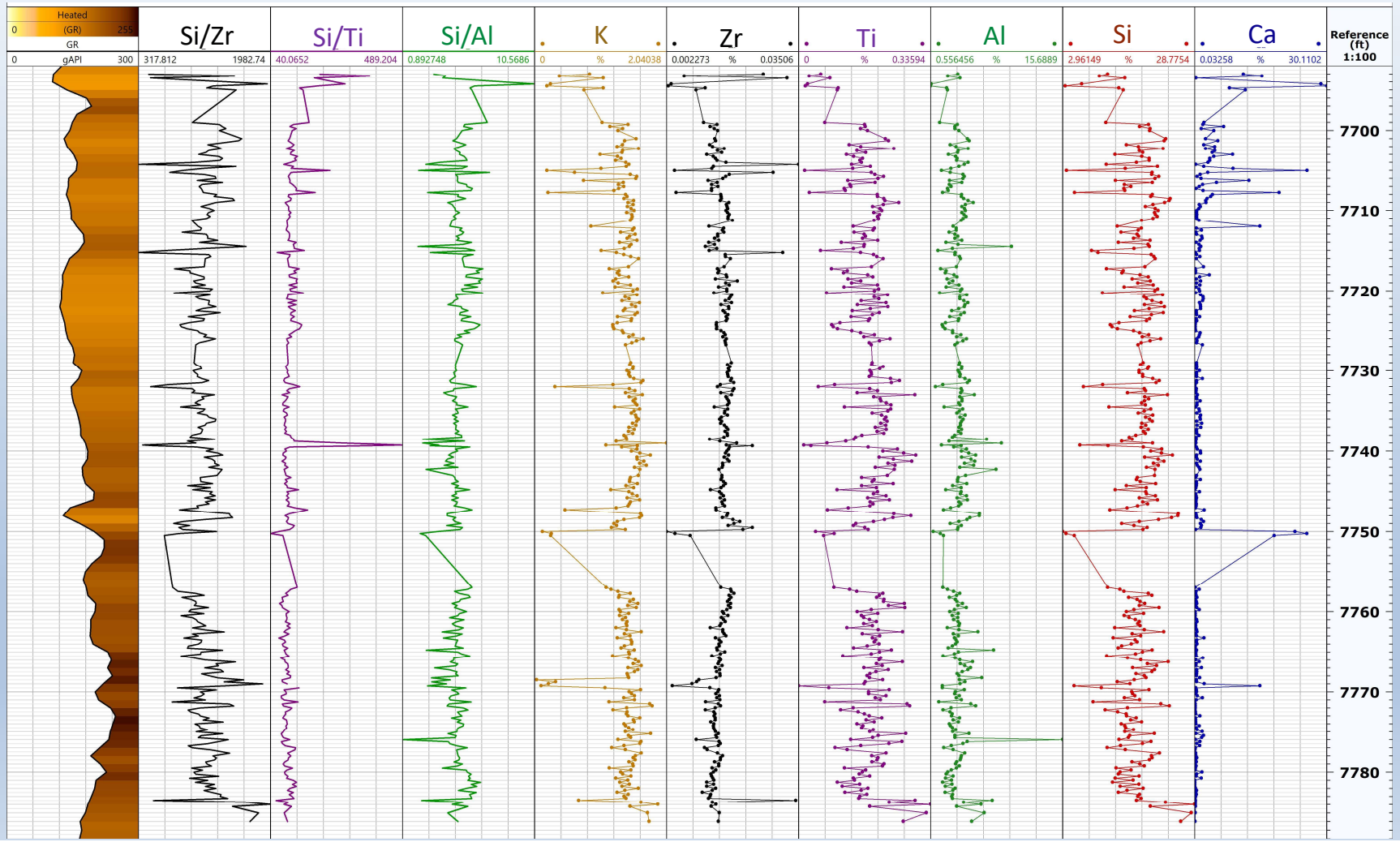
Core Overview – Coland State

- Started measurements at the X-bentonite.
- Foraminifera sand at the top.
- Trace fossils:
  - Inoceramid shells
  - Ammonites
- Fish scales and bones on bedding planes.
- Pyrite throughout in the form of nodules and disseminated pyrite.
- Ash layers
  - 7715.25’, 7739.25’, 7783.5’
- The Thatcher Limestone is present.
  - 7750’

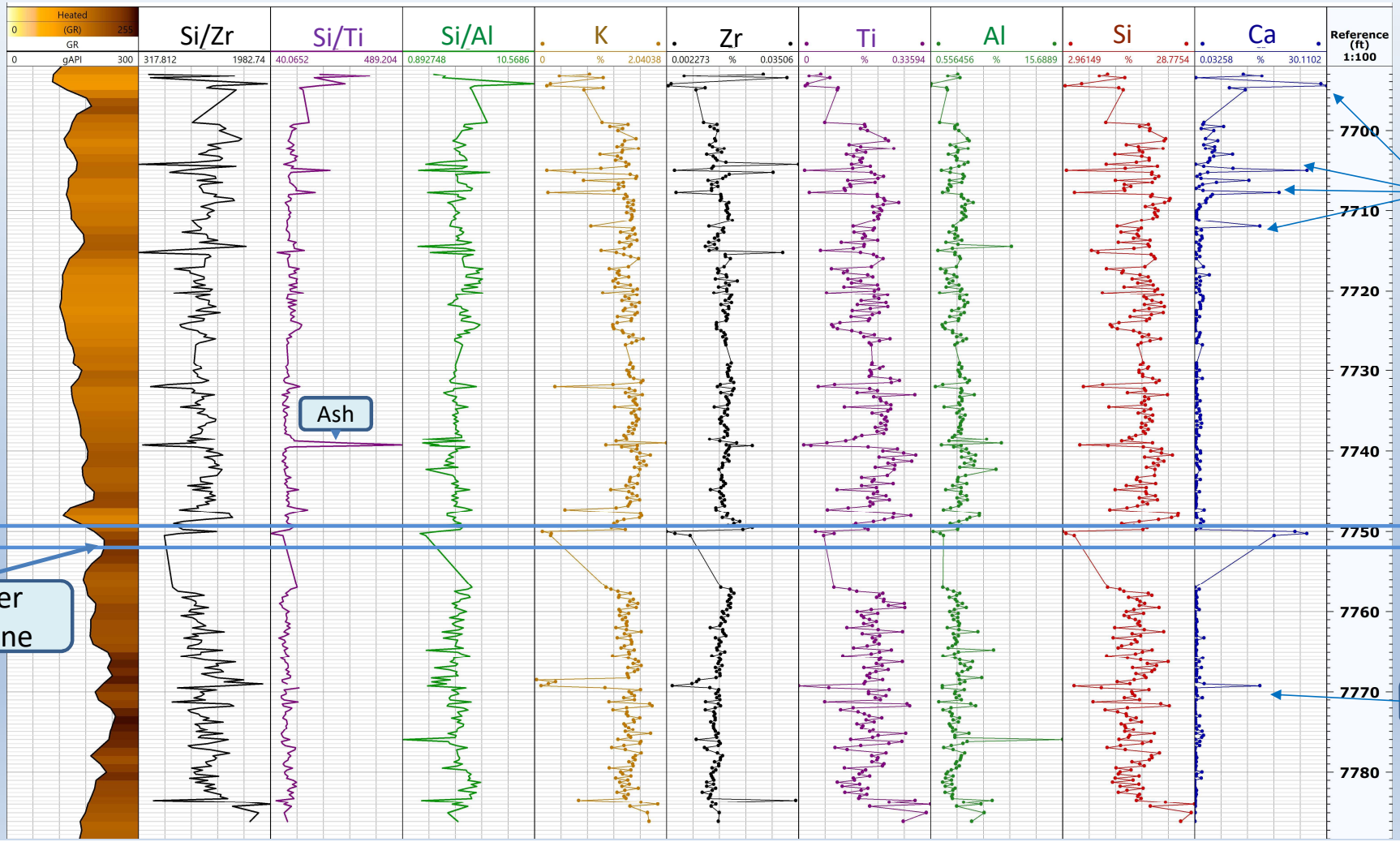
Inoceramid shell

Thatcher Limestone Member

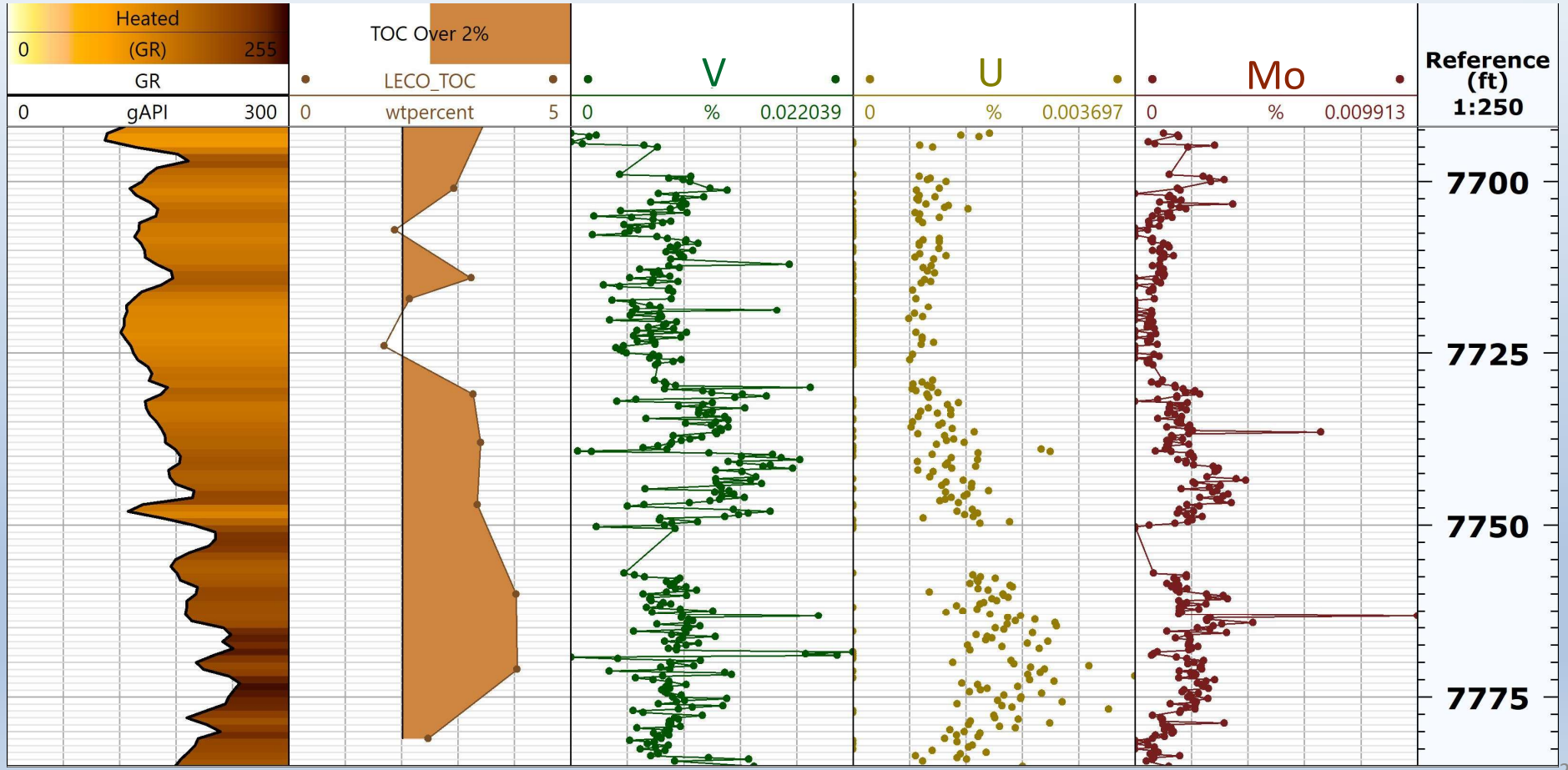
Coland State – Detrital Indicators



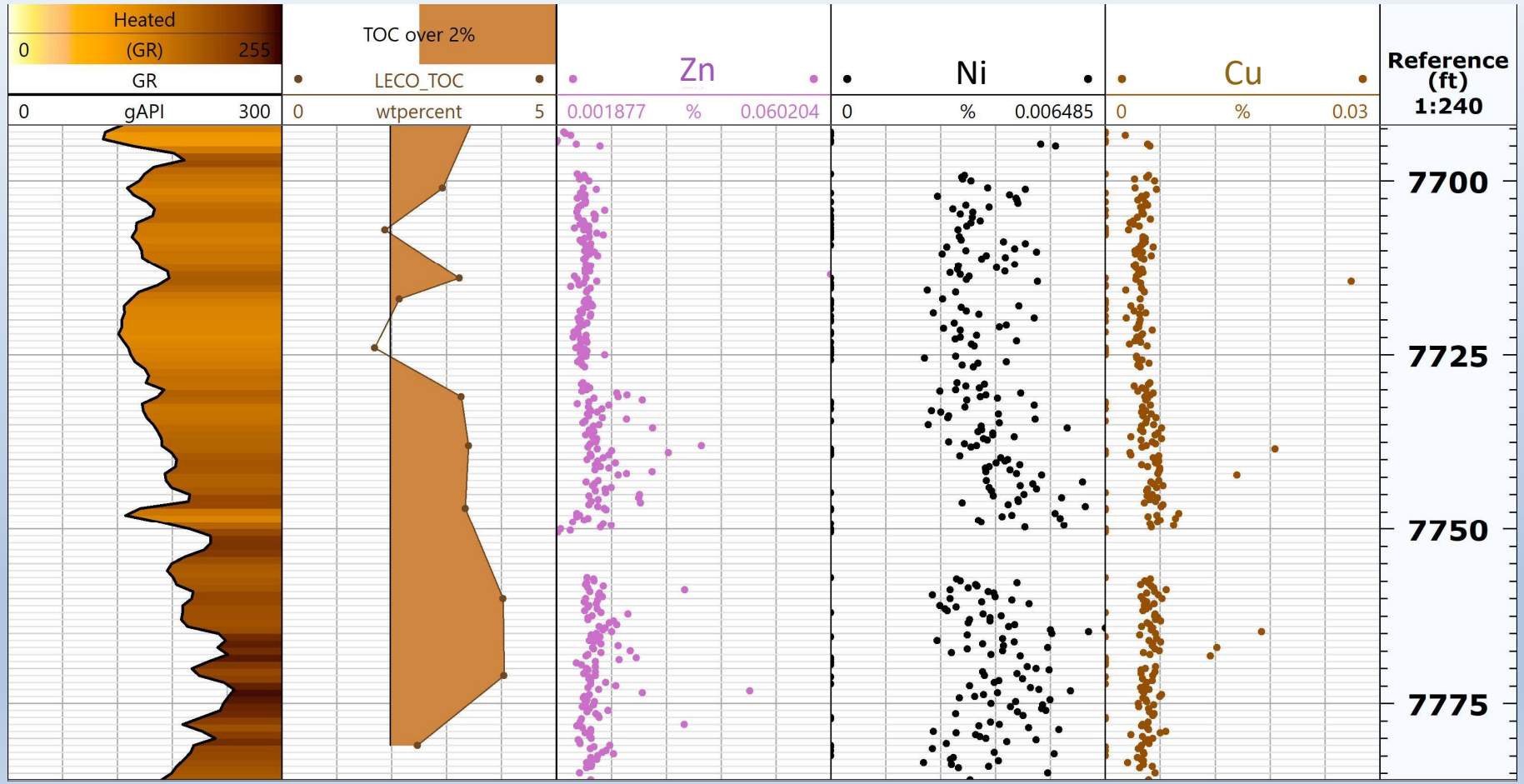
Coland State – Detrital Indicators



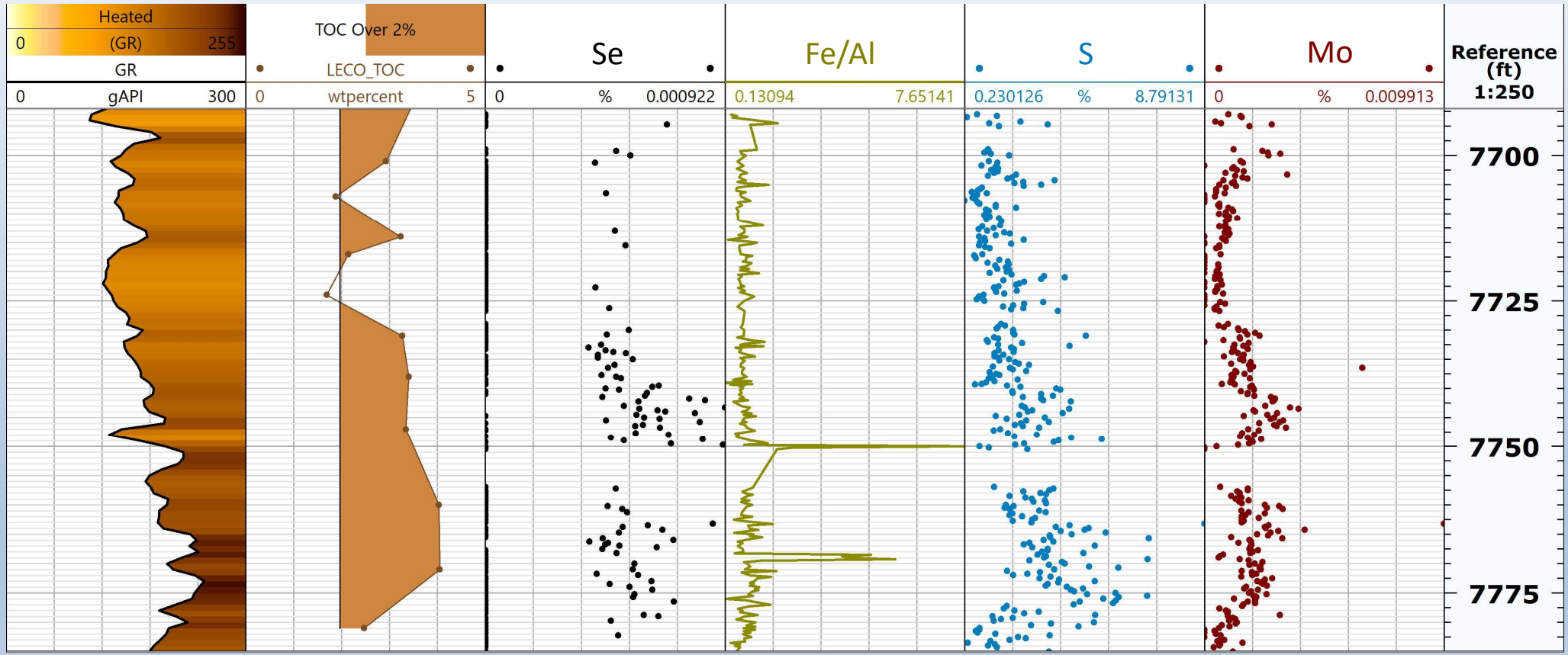
Coland State – Redox Sensitive Trace Elements



Coland State – Organophillic Trace Elements

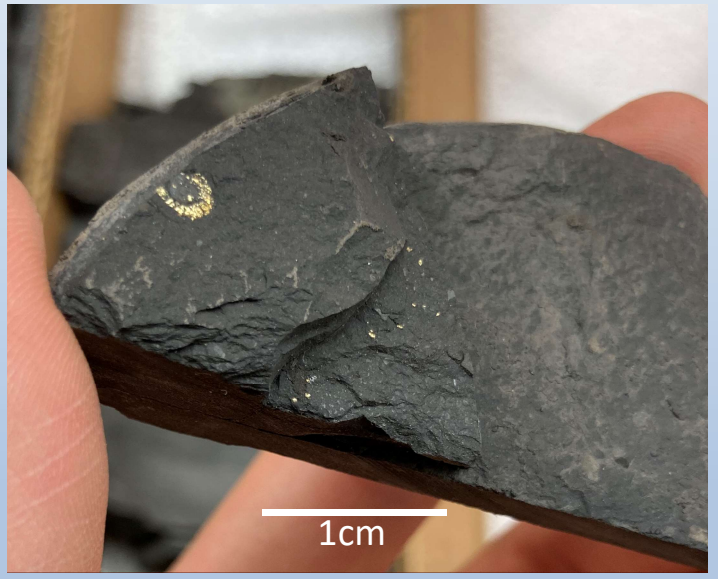


Coland State – Euxinia Proxies



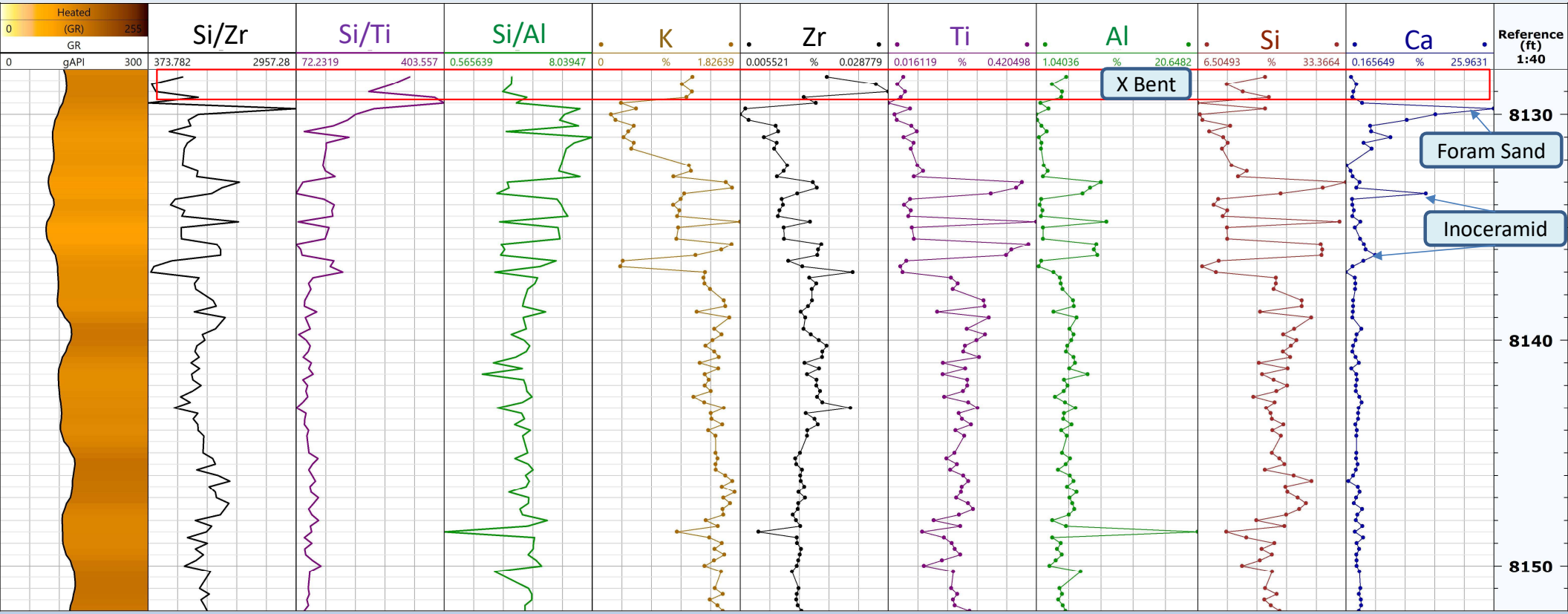
Howard - Overview

- Starts at the X bentonite.
- Mixed foraminifera sand at the top.
- Fossils:
  - Inoceramid shell
  - Ammonites
- Fish scales and bones on bedding plane.
- Pyrite nodules and disseminated pyrite throughout.

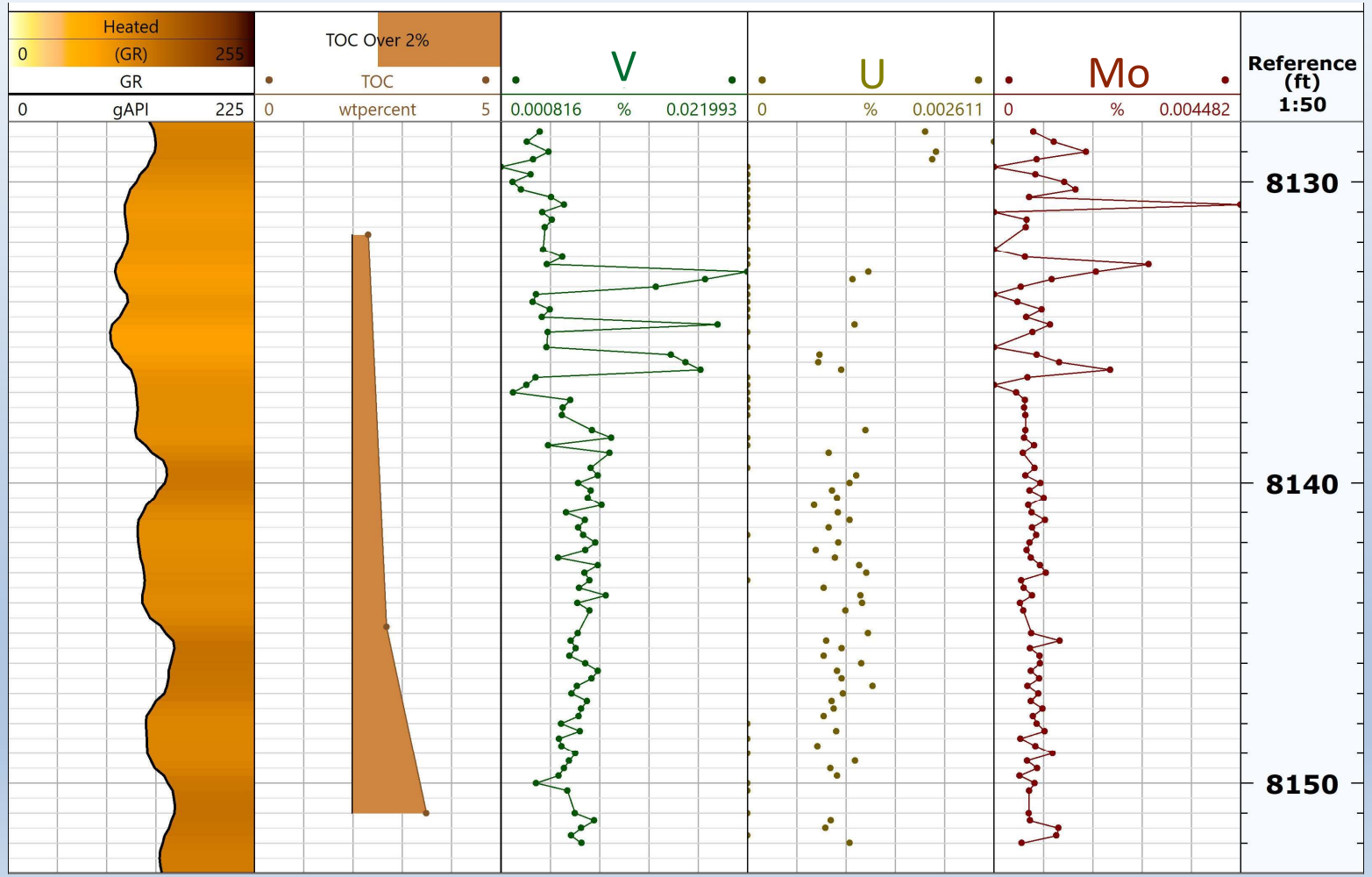


Pyrite replaced ammonite.

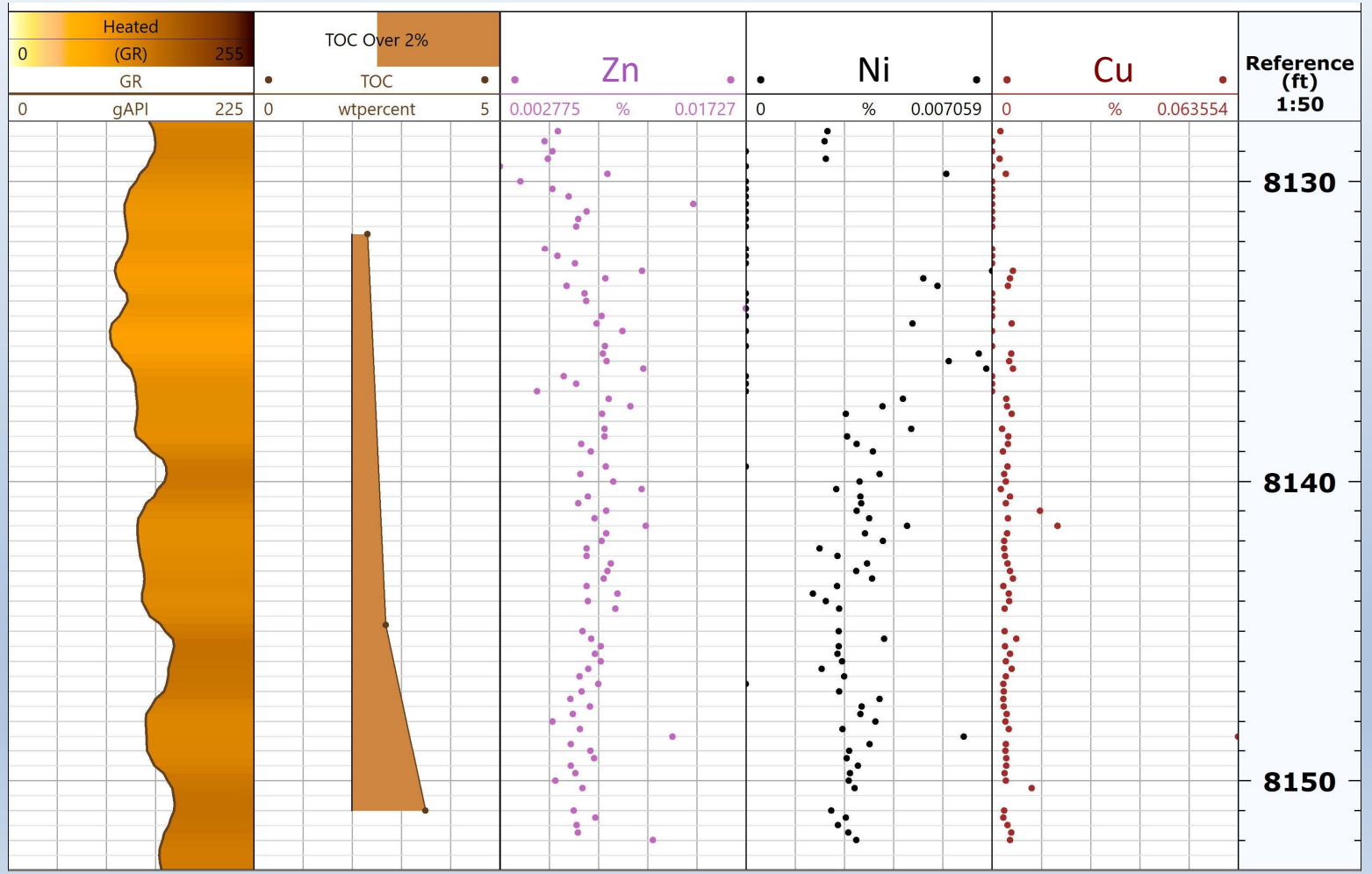
Howard – Detrital Indicators



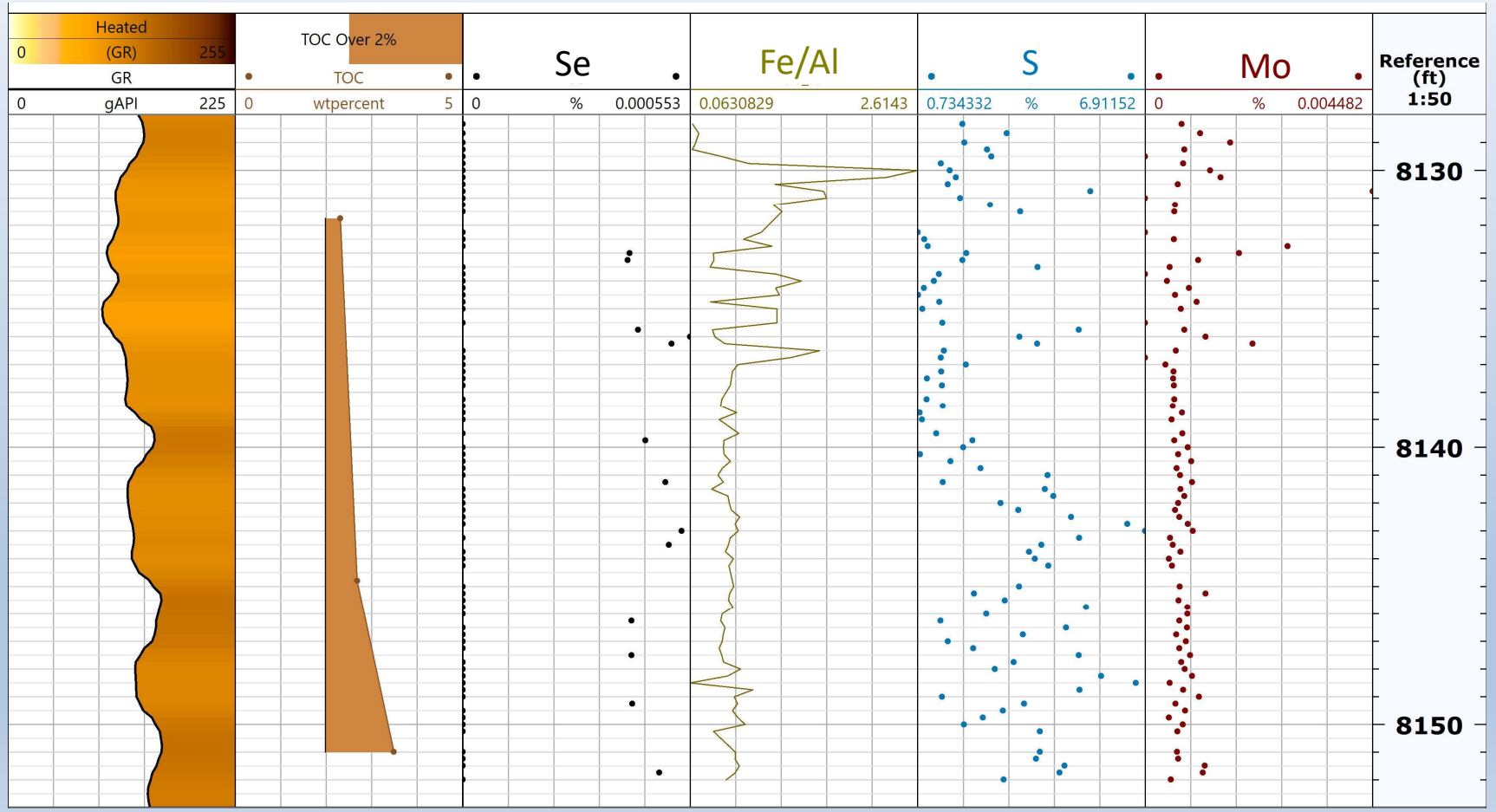
Howard – Redox Sensitive Trace Elements



Howard – Organophillic Trace Elements

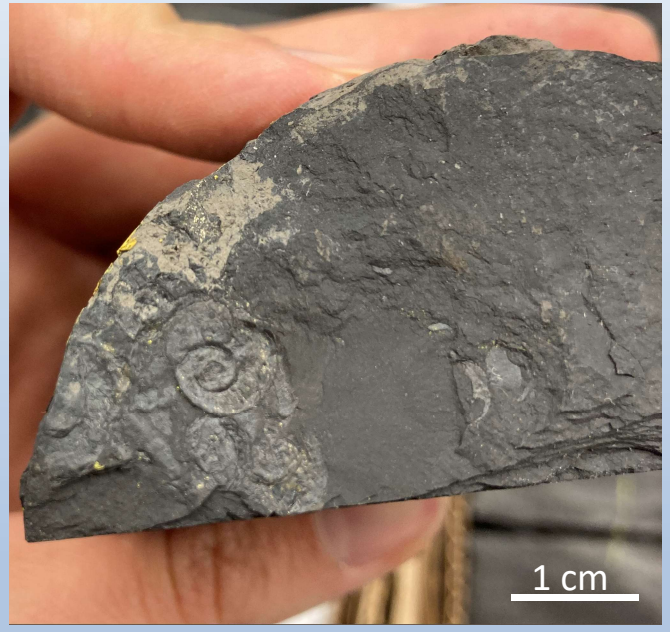


Howard – Euxinia Proxies



Conclusions

- The Graneros Shale is dominated by detrital sediment.
- Organophillic elements don't impact TOC that much.
- The Graneros was deposited in a oxygen-depleted and a more reduced environment.



Ammonites in the Coland State

Future Work

- Detailed core description.
- Build mineral models for each core.
  - Incorporate XRD.
- Incorporate source rock analysis.
  - Already have data.
- Ion milling.
- FE-SEM imaging.

MUDTOC Consortium Sponsors
Fall 2021

Colorado School of Mines MUDTOC

Sponsoring Member Companies

Anschutz Exploration Corporation

Antero Resources

Bonanza Creek

Chevron

Cimarex

Crestone Peak Resources

devon

Enverus

EOG Resources

GMT Exploration Company LLC

OXY

Red Willow Production Company

Shell

TGS

White Eagle Exploration

Whiting

In-Kind Supporting Companies

GeoMark

IHS

Mike Johnson & Associates

MJ Logs

PRA Platte River Associates, Inc.

Schlumberger

Stratum Reservoir