Slide 1

Presentation #3

- Solid-phase geochemistry, uses data from U.S Geological Survey Open-File Report 2013-1093
  - Johnson, R.H., Diehl, S.F., and Benzel, W.M., 2013, Solid-phase data from cores at the proposed Dewey Burdock uranium in-situ recovery mine, near Edgemont, South Dakota: U.S. Geological Survey, Open-File Report 2013-1093, 13 p. (http://pubs.usgs.gov/of/2013/1093/)
- Part of presentation to the EPA on February 22, 2012 and part of presentation to USGS uranium group on March 6, 2012

Slide 2

Solid-phase geochemistry at the Proposed Dewey Burdock Uranium In-Situ Recovery Mine, Edgemont, South Dakota

By Raymond H. Johnson

USGS
science for a changing world

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Slide 3

This presentation

- Summarize new USGS solid-phase data collection from cores

Slide 4

Solid-phase Geochemistry

- Total carbon and total sulfur
- Whole rock (majors and trace elements)
- X-ray diffraction
- Thin sections, Scanning Electron Microscopy
- Key to think about – can we get samples to analyze reducing capacity that are equivalent to “out in front” of the ore zone

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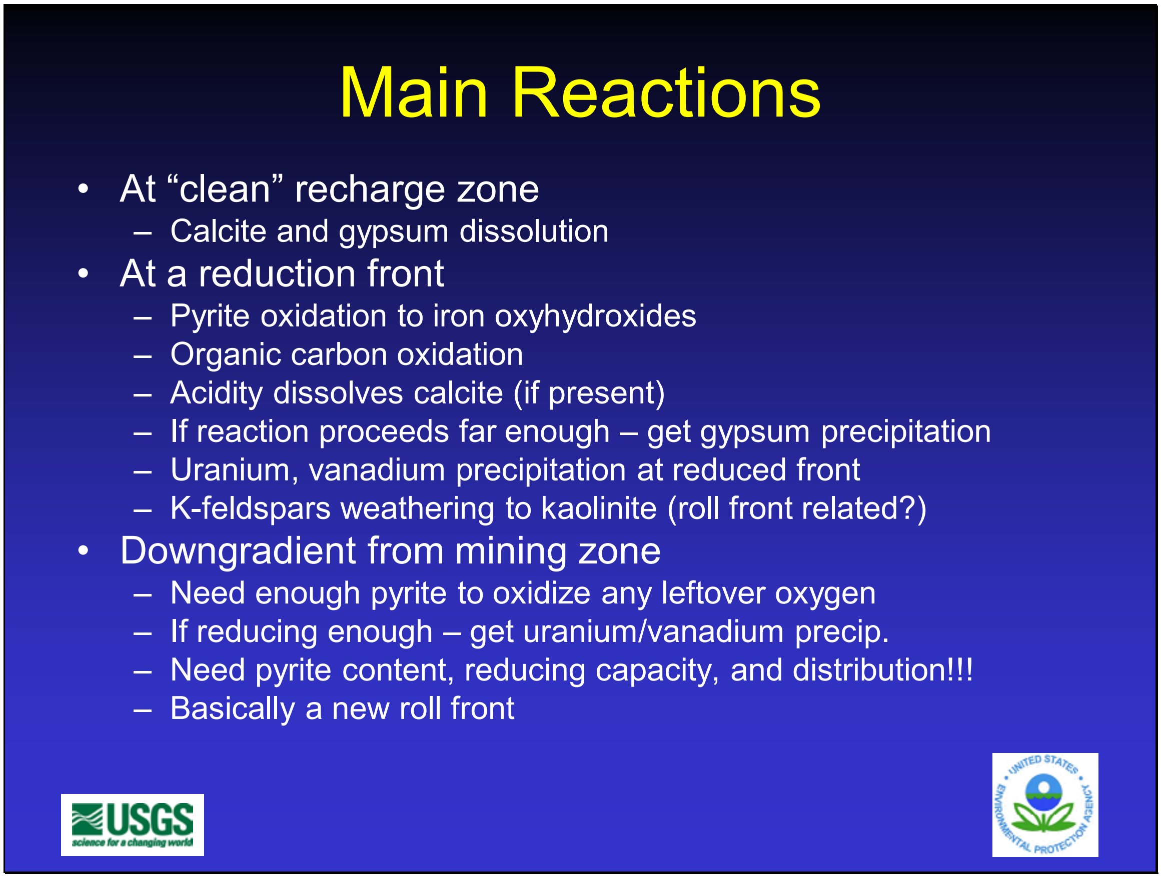
“Out in front” being on the reducing side of a redox front, but with no uranium ore.

Slide 5

Study Goals

- Resources side
  - – Roll front formation processes
- Environmental side
  - – Can we get samples to analyze reducing capacity that are equivalent to “out in front” of the ore zone
  - – Need to simulate post-mining reactions (natural attenuation)

Slide 6



These are generalized roll front reactions that also apply to the Dewey Burdock area.

Slide 7

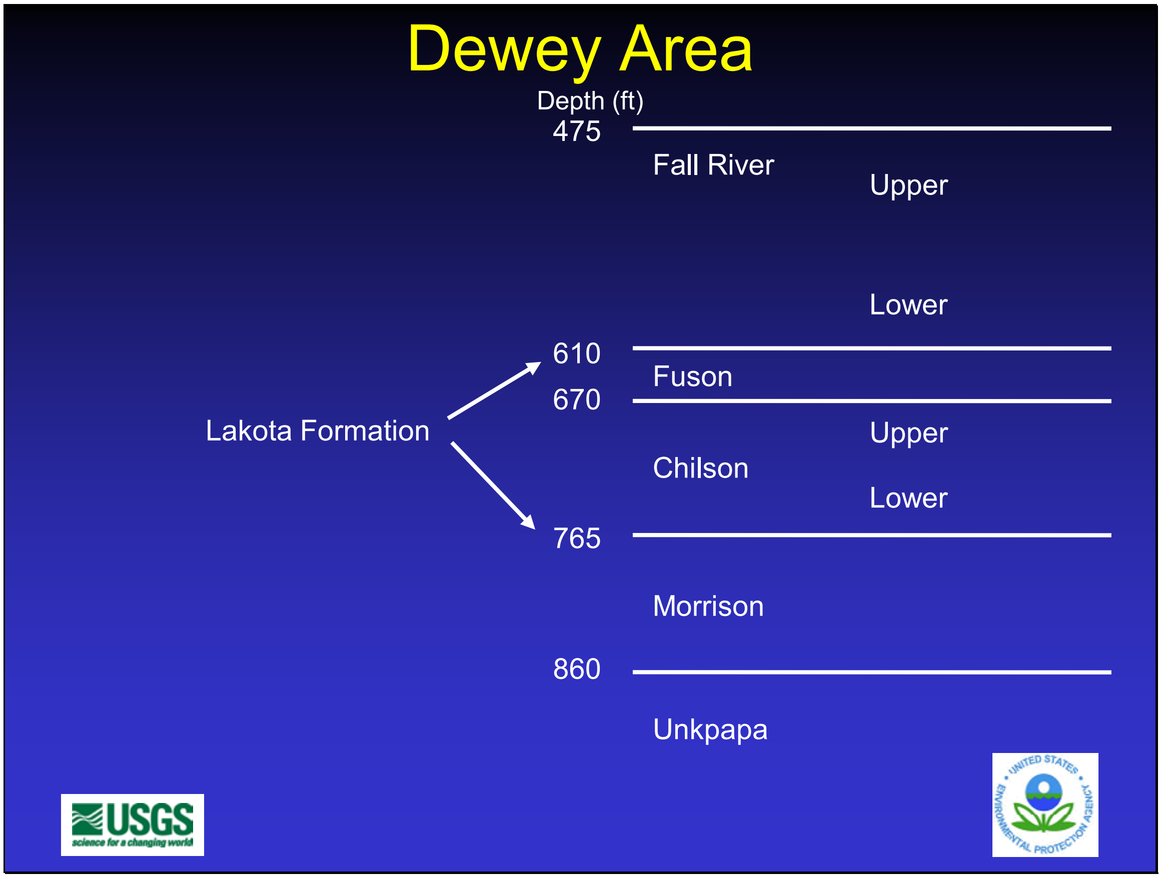
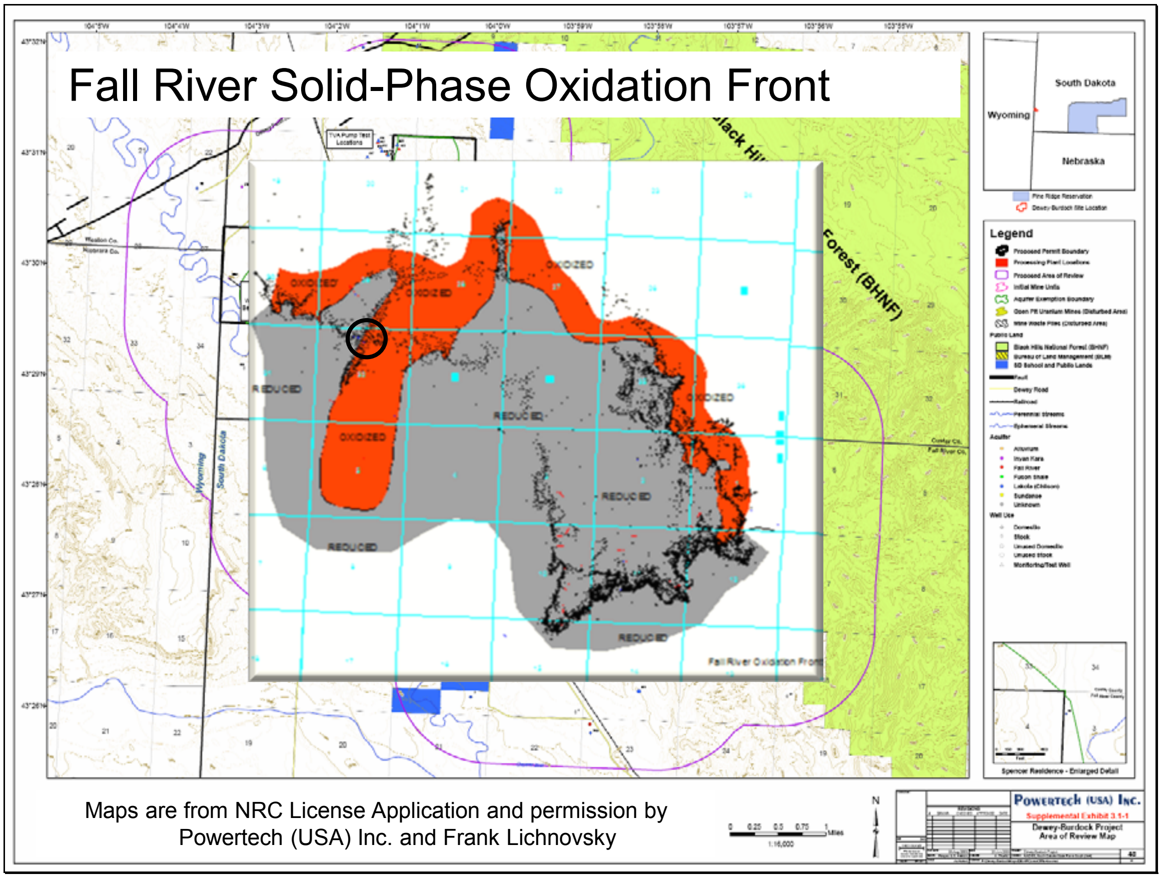


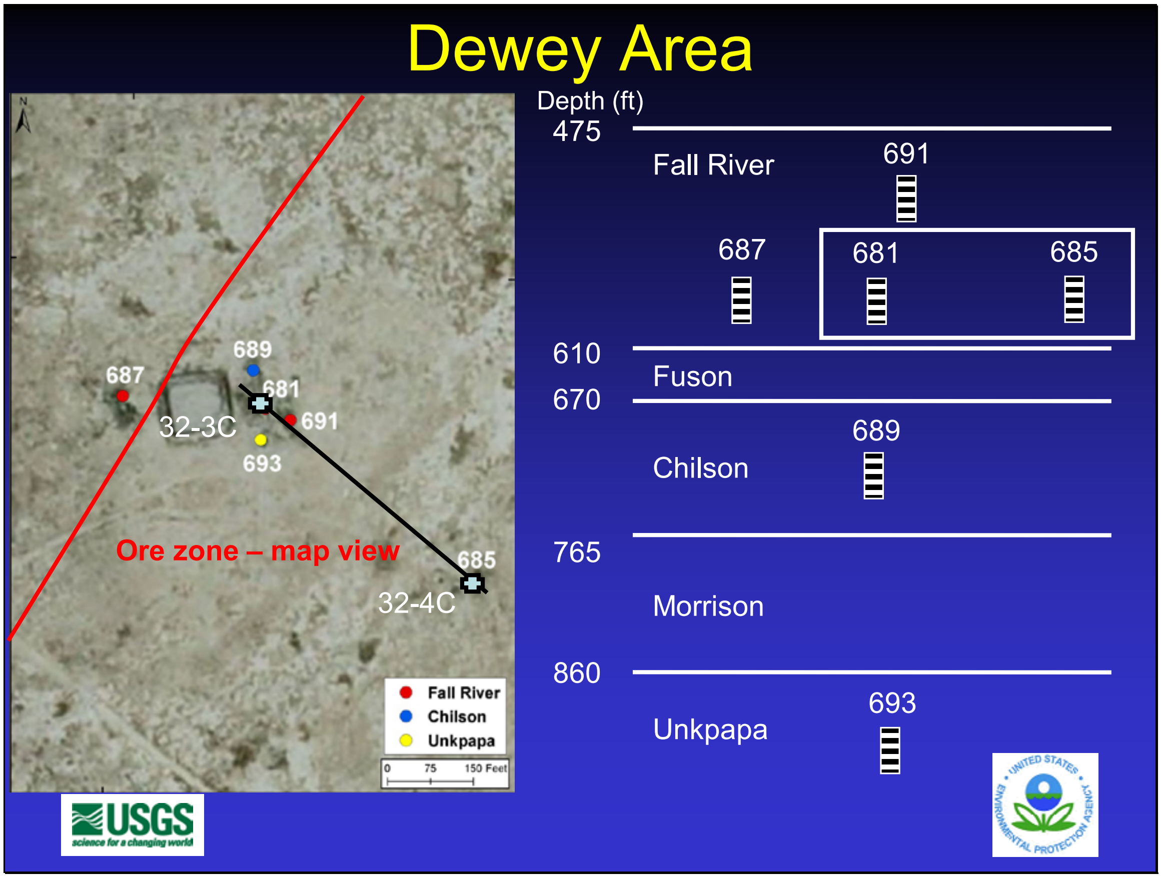
Diagram of stratigraphy.

Slide 8



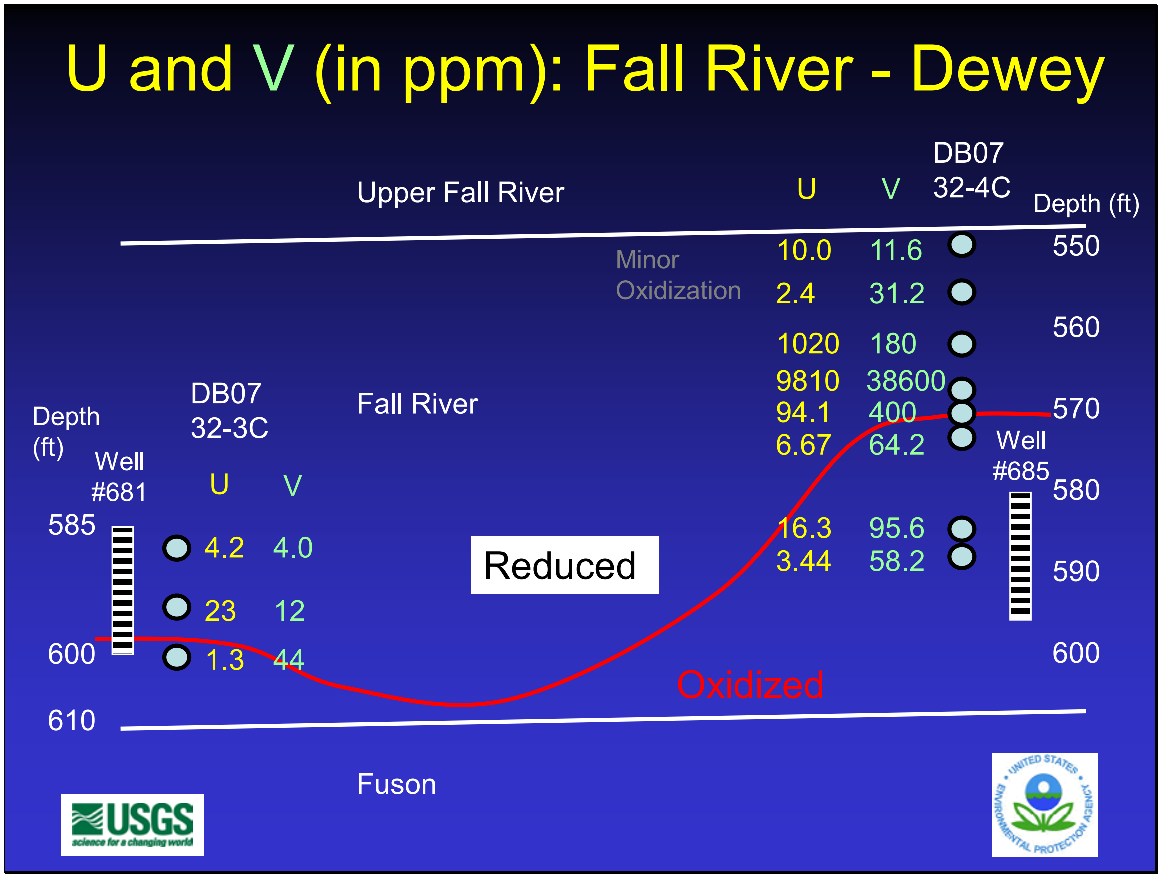
Black circle indicates coring location.

Slide 9



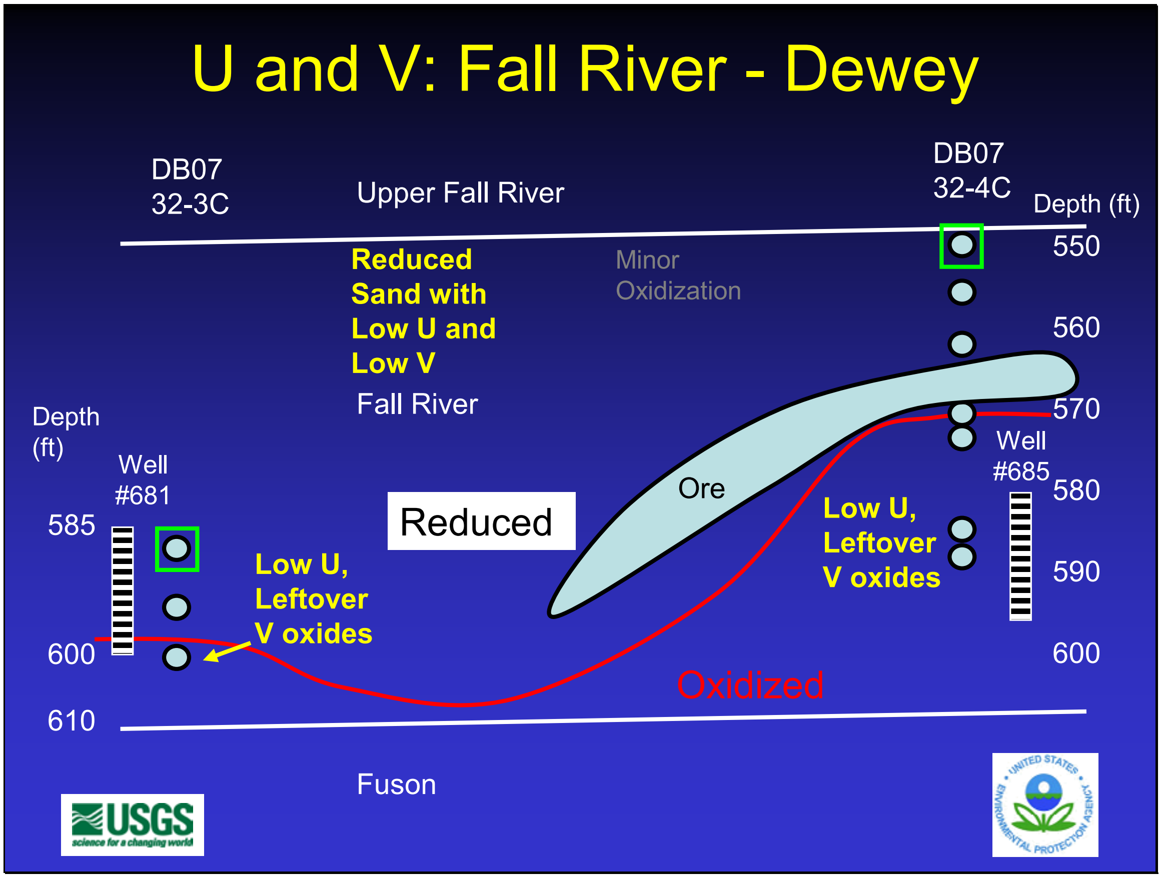
Core locations are indicated by the blue crosses.
Cores were taken from monitoring wells 681 (core 32-3C) and 685 (core 32-4C).
Black line indicates cross section location that is provided in the next slide.

Slide 10



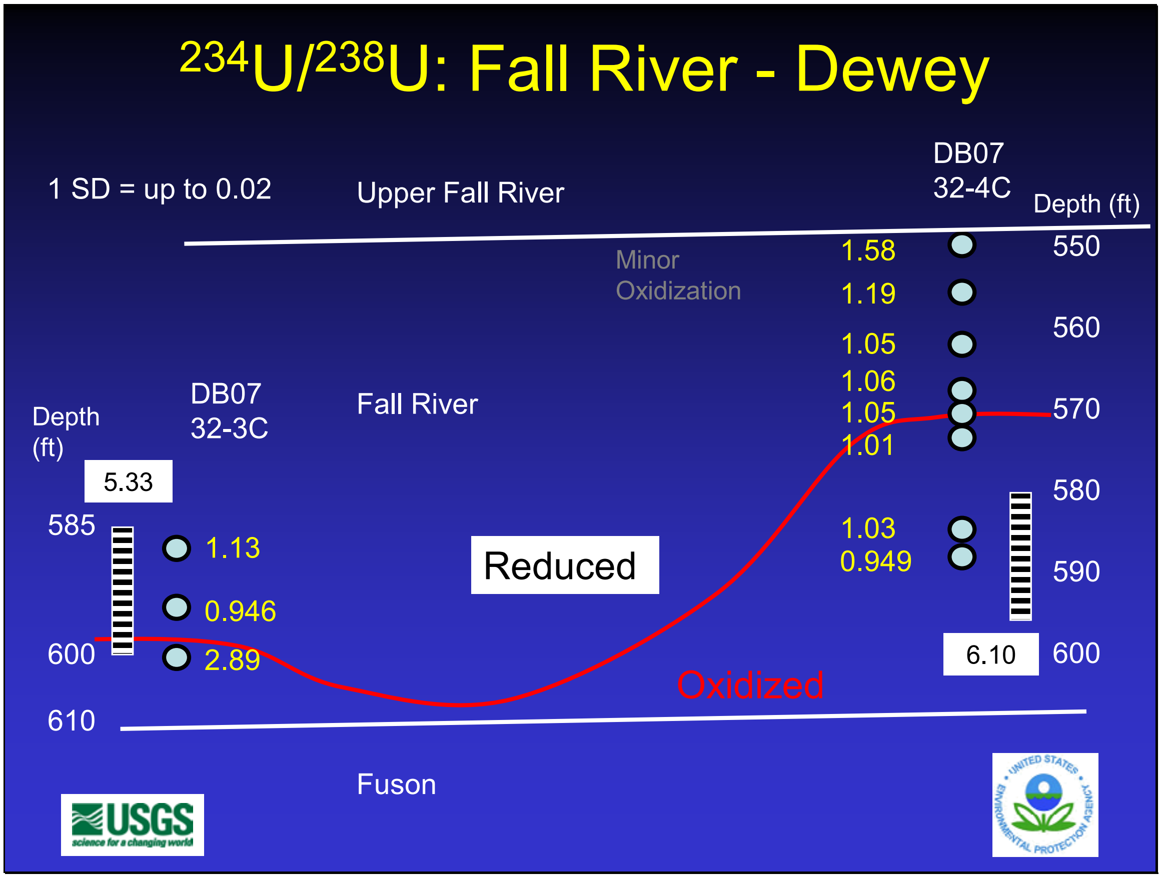
This and subsequent diagrams are cross sections with locations of solid phase samples, well screen depths, stratigraphy, and sample results.
All well screens (rectangles with lines) and sample locations are drawn to scale in this and all further slides.
Current groundwater flow here is coming approximately out of the page.

Slide 11



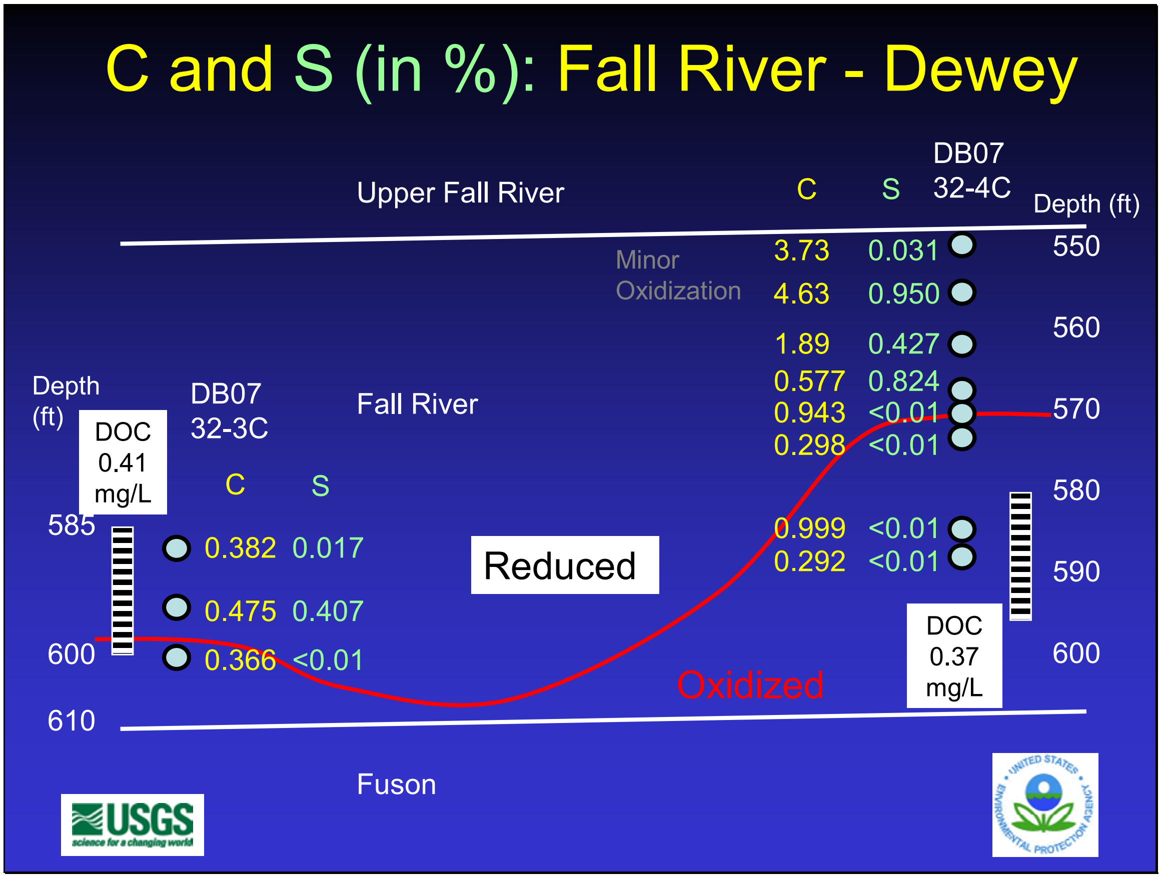
Green boxes indicate good reduced samples with no uranium deposit, which are good "out in front" of the roll front equivalents.

Slide 12



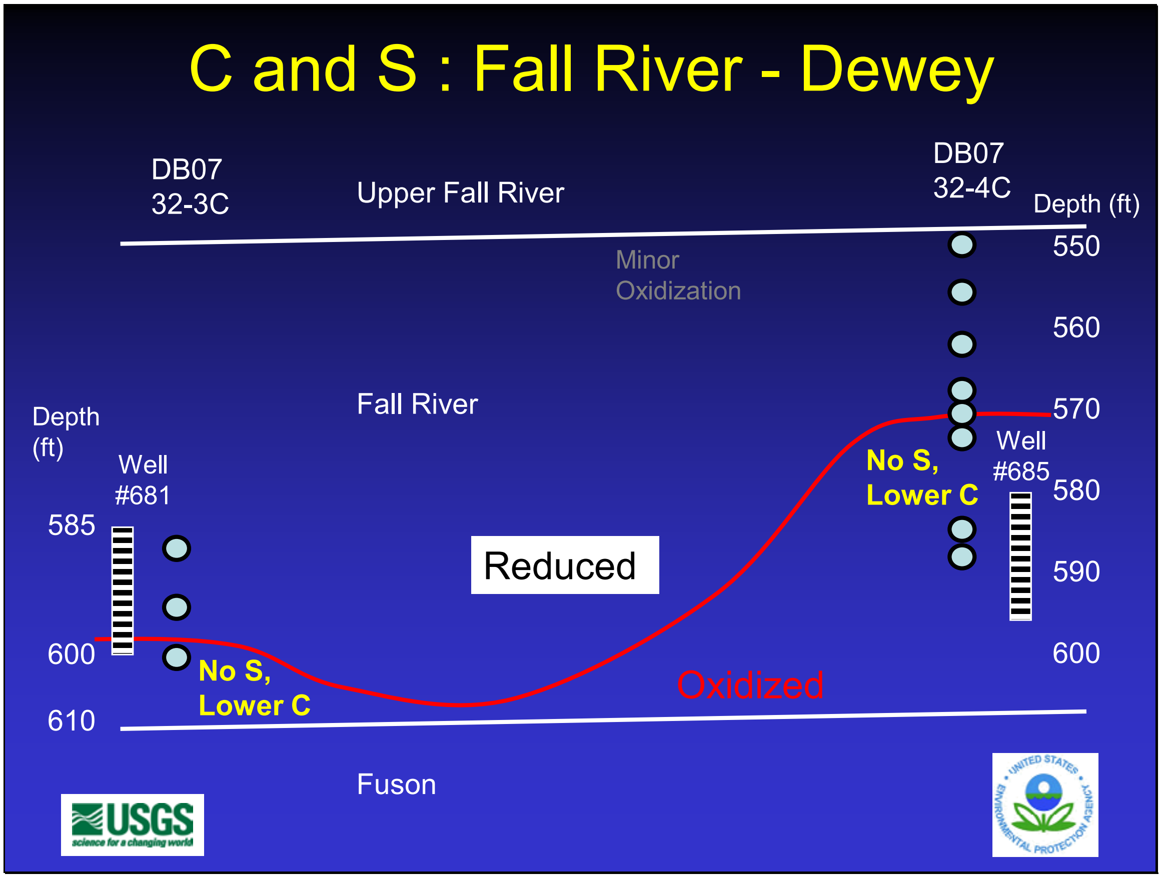
White box at well screen indicates uranium isotope value in groundwater.
SD = standard deviation.

Slide 13



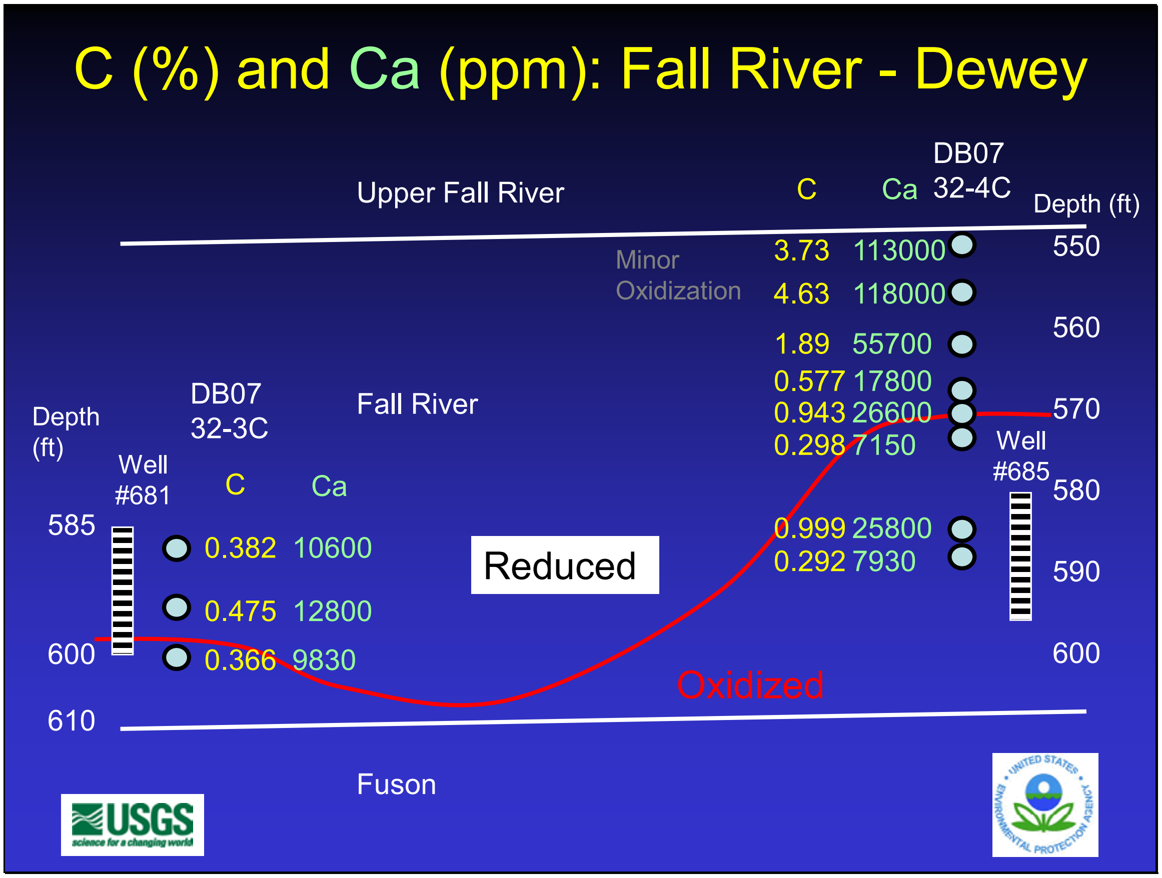
DOC = dissolved organic carbon.
White box at well screen indicates DOC value in groundwater.

Slide 14



Simplified summary slide for C and S, with influence of oxidized zone.

Slide 15



C (%) and Ca (ppm): Fall River - Dewey
Upper Fall River
C
Ca
DB07
32-4C
Depth (ft)
550
560
570
580
590
600
Minor
Oxidization
3.73 113000
4.63 118000
1.89 55700
0.577 17800
0.943 26600
0.298 7150
0.999 25800
0.292 7930
Well
#685
Fall River
DB07
32-3C
Depth
(ft)
Well
#681
C
Ca
585
0.382 10600
0.475 12800
0.366 9830
600
610
Reduced
Oxidized
Fuson
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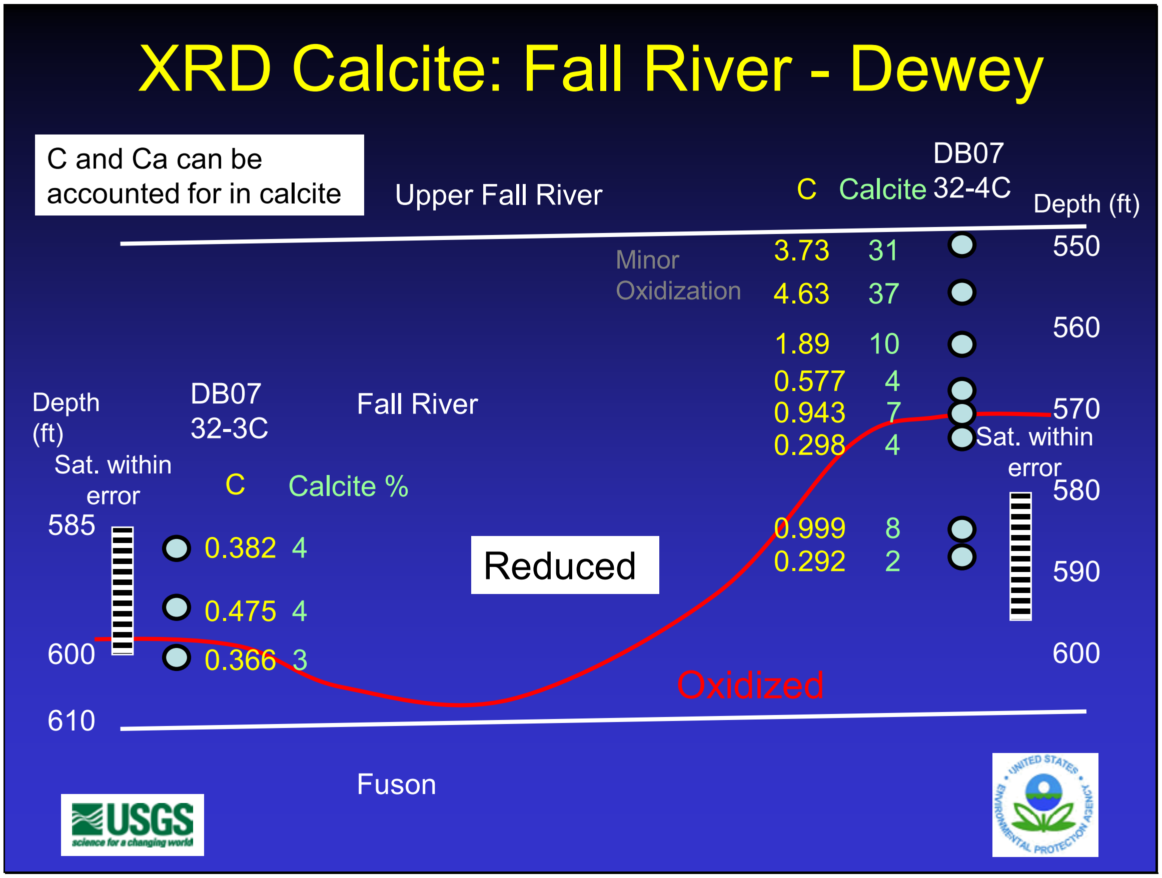
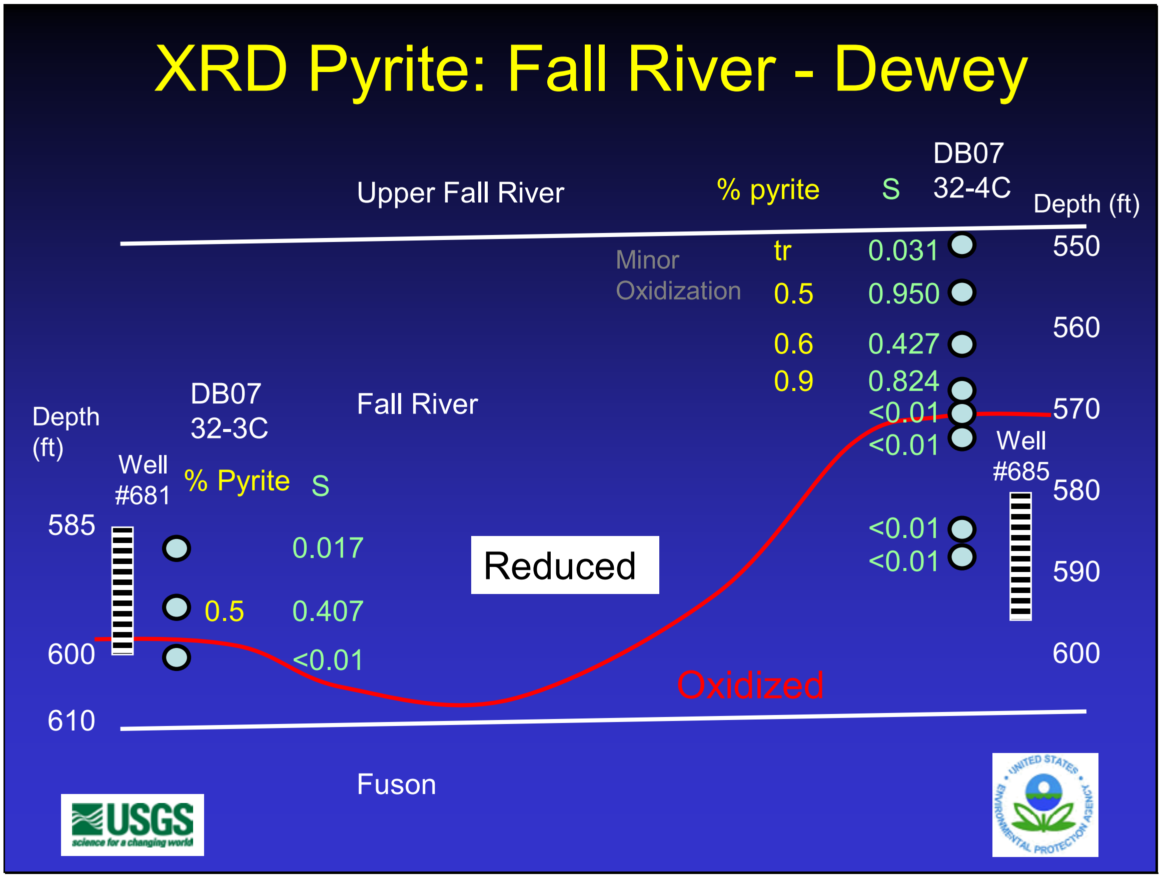


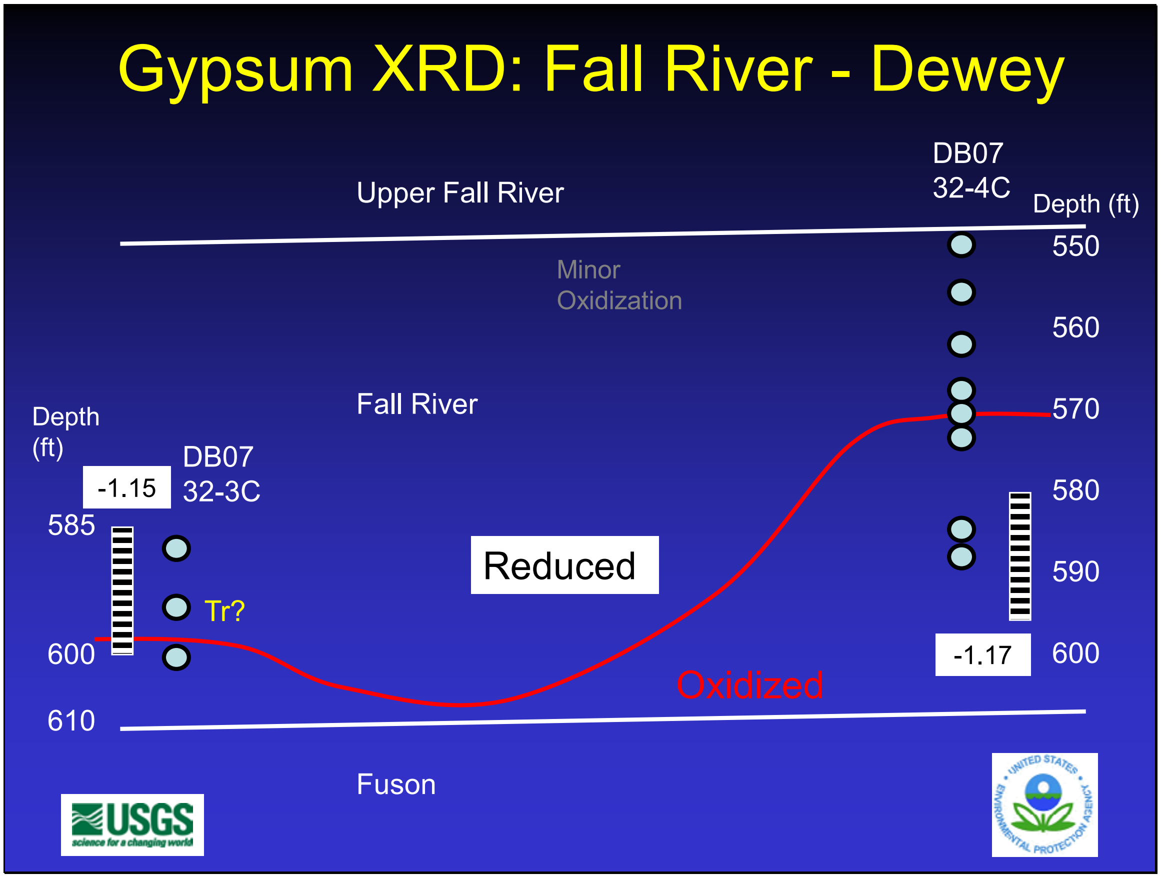
Sat. within error = analyses in these wells for calcite indicate fully saturated (i.e., in equilibrium), within analytical error.

Slide 17



Sulfur % listed for reference.
Majority of sulfur is accounted for by pyrite.

Slide 18



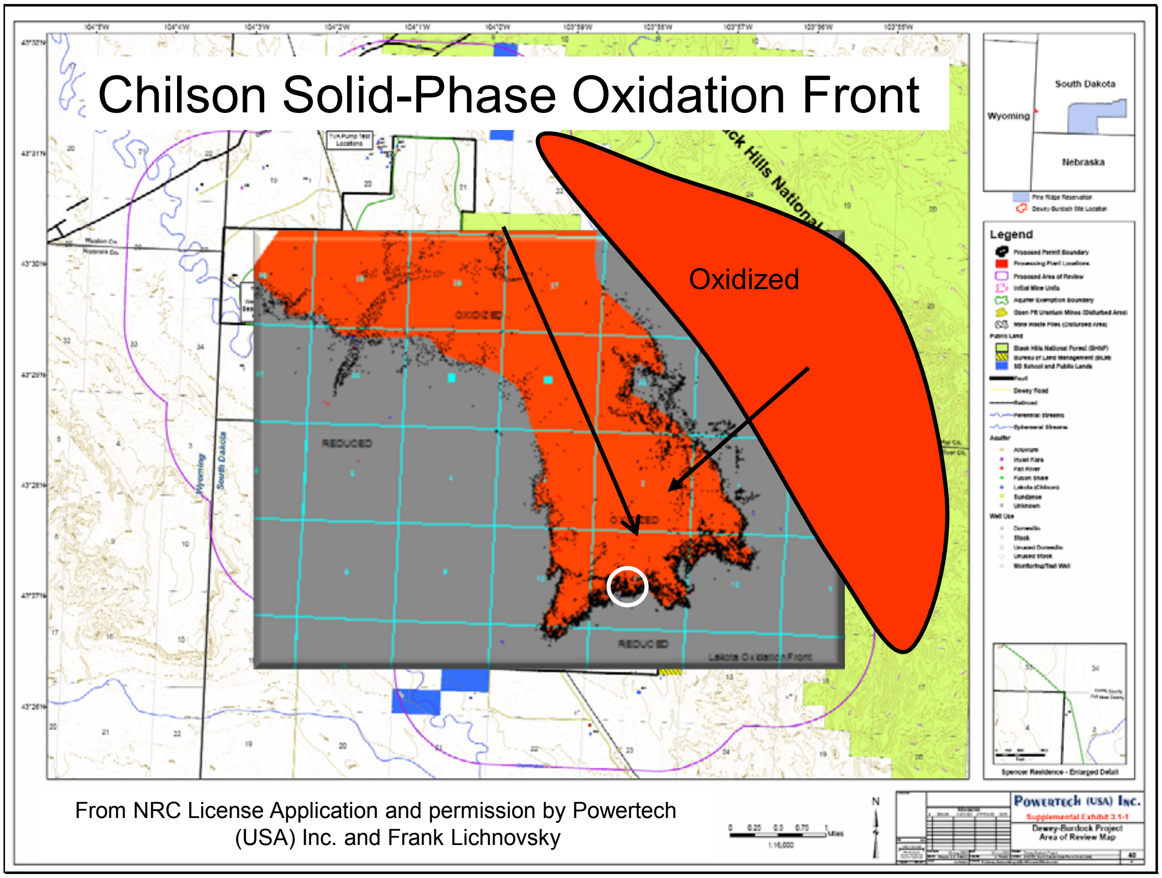
White box at well screen indicates calculated gypsum saturation index in groundwater. In the Dewey area, only one sample had a trace of gypsum.

Slide 19

Dewey Summary and Interpretations

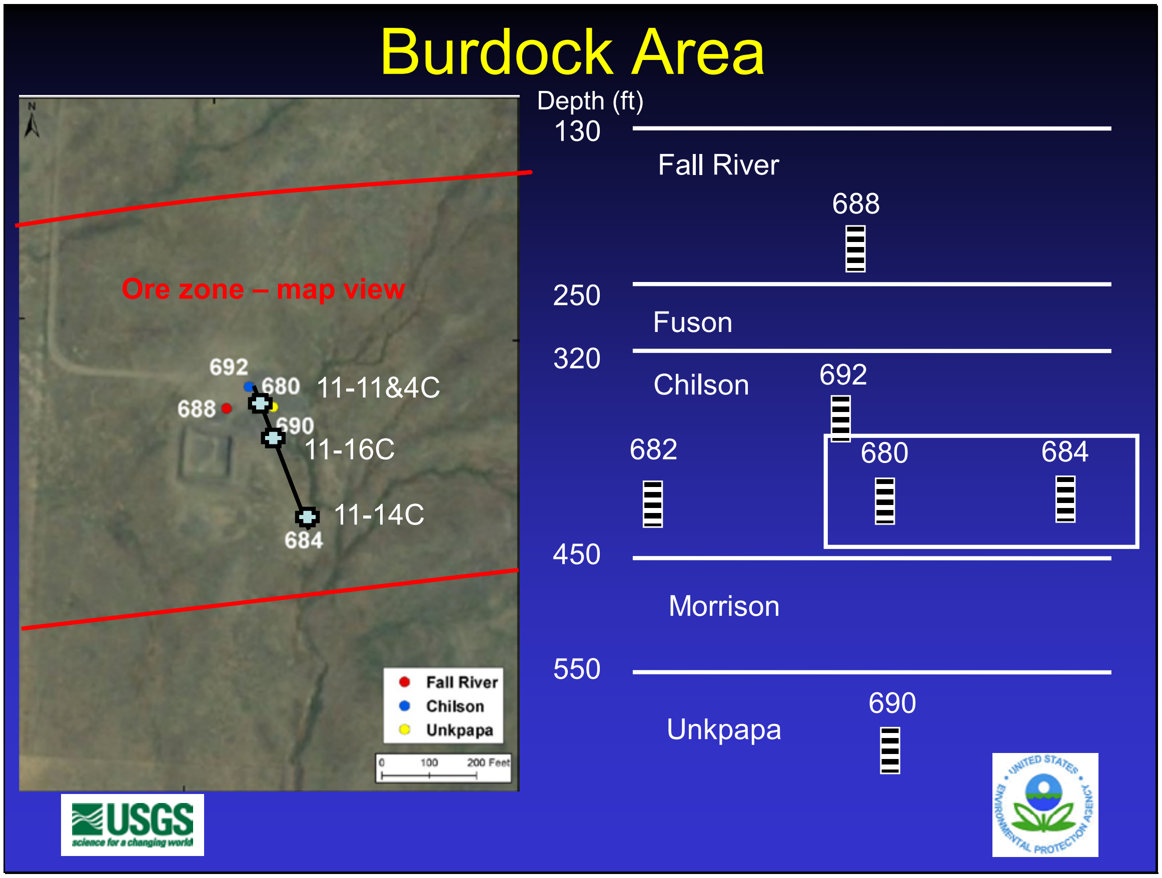
- Majority of U isotopes ratios in the solid phase are near one, indicating very little ore movement in the last 1-2 million years (influence of Dewey fault zone?)
- Solid phase carbon content is accounted for by calcite
- High vanadium content in the solid phase
- Sulfur content is accounted for by pyrite (around 0.5 wt. % in reduced zones) and possibly some trace gypsum
- Key indicators of the oxidized zone
  - Very low sulfur content (pyrite oxidized to hematite)
  - Red color in cores (oxidized iron)

Slide 20



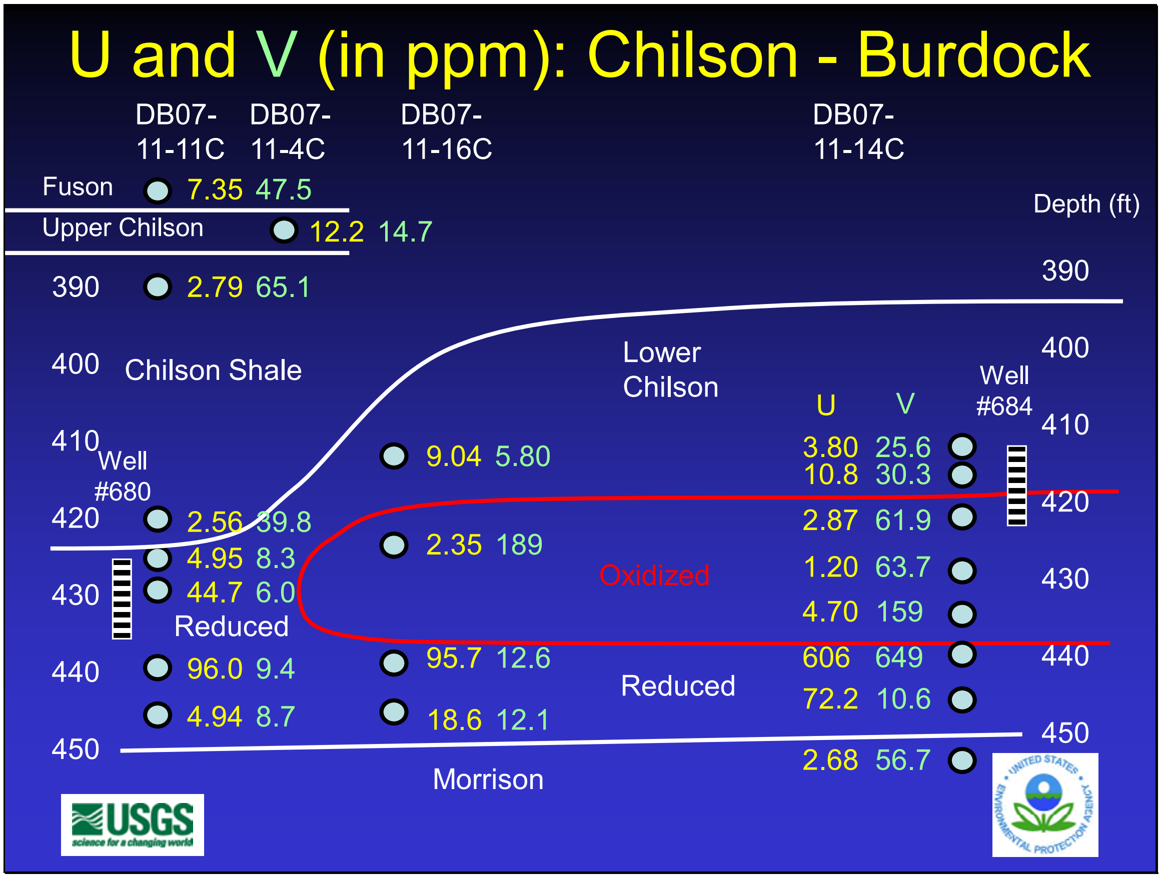
White circle indicates core location.
Southeast pointing arrow indicates paleogroundwater flow direction for roll front formation and southwest pointing arrow indicates current groundwater flow direction. Large oxidized zone on the east side was added as a reasonable interpretation that the outcrop zone of the Chilson is oxidized (no core is available in this area).

Slide 21



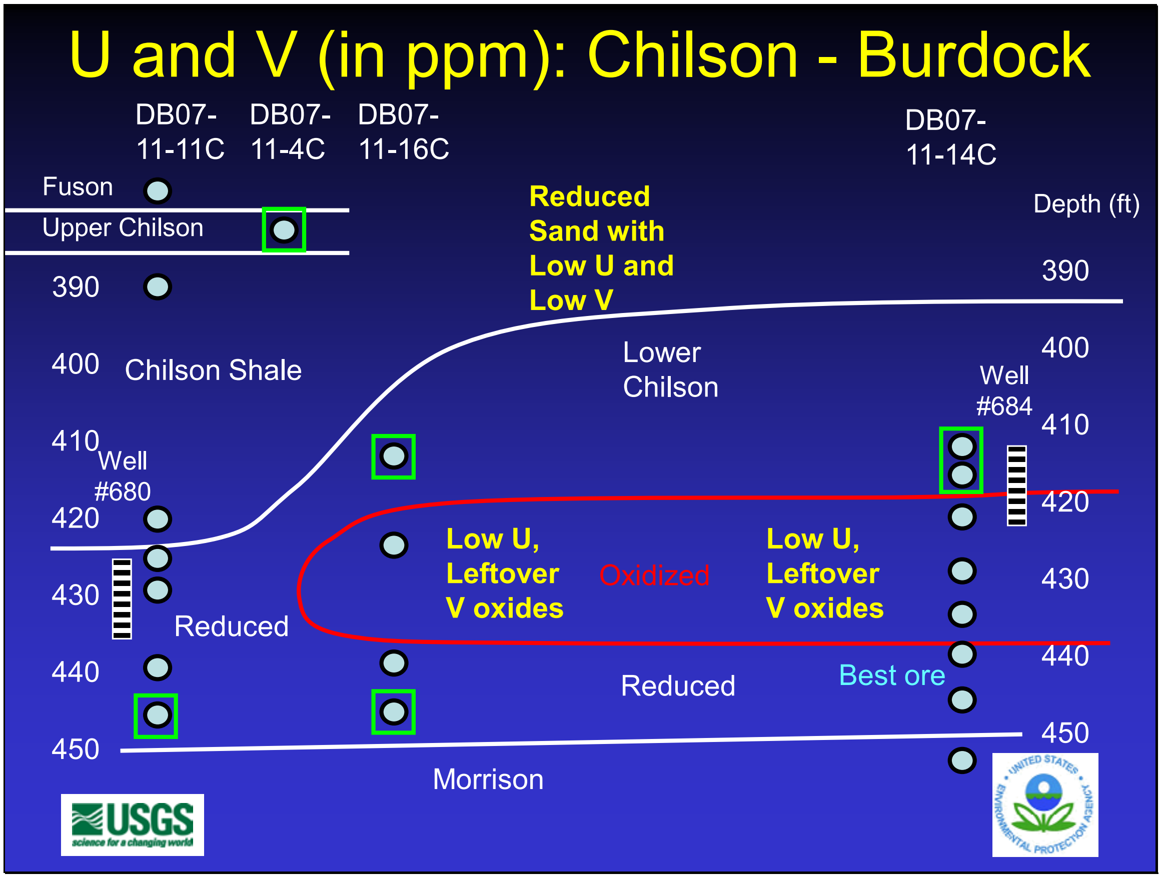
Core locations are indicated by the blue crosses.
Cores were taken from monitoring wells 680 (core 11-11C and 11-4C) and 684 (core 11-14C). 11-16C was an independent core hole.
Black line indicates cross section location that is provided in the next slide.

Slide 22



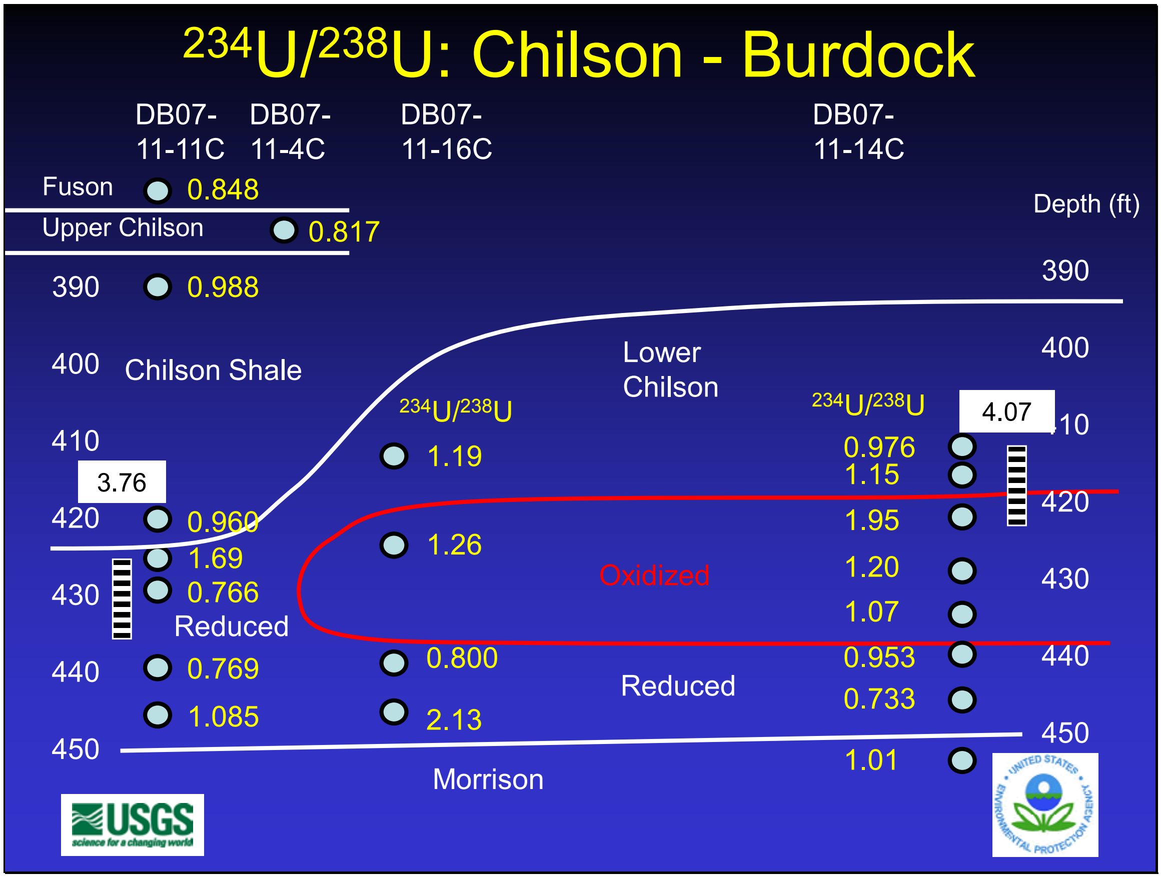
This and subsequent diagrams are cross sections with locations of solid phase samples, well screen depths, stratigraphy, and sample results.
All well screens (rectangles with lines) and sample locations are drawn to scale in this and all further slides.
Current groundwater flow here is coming approximately right to left, parallel with the page.
Data from the Fuson and Upper Chilson Members of the Lakota Formation are provided in the upper left corner, but depth is not to scale.

Slide 23



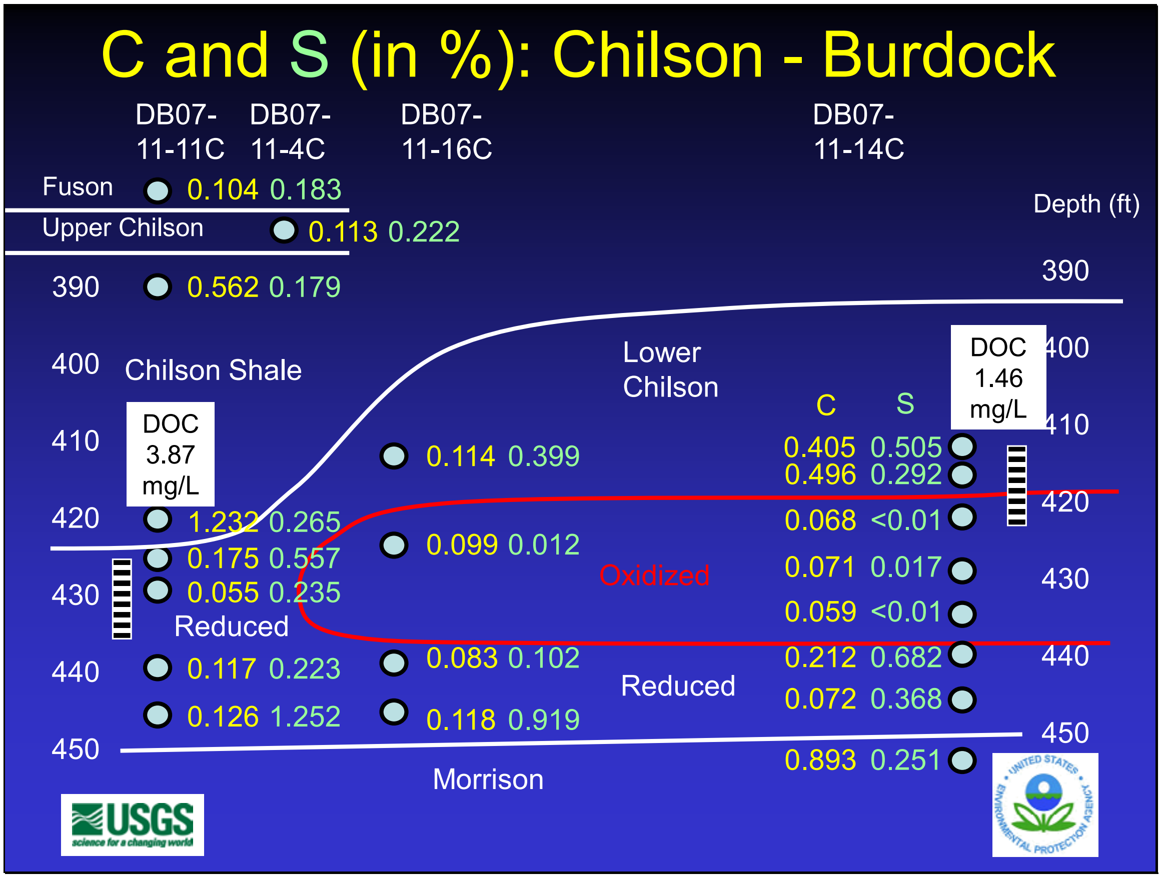
Green boxes indicate good reduced samples with no uranium deposit, which are good "out in front" of the roll front equivalents.

Slide 24

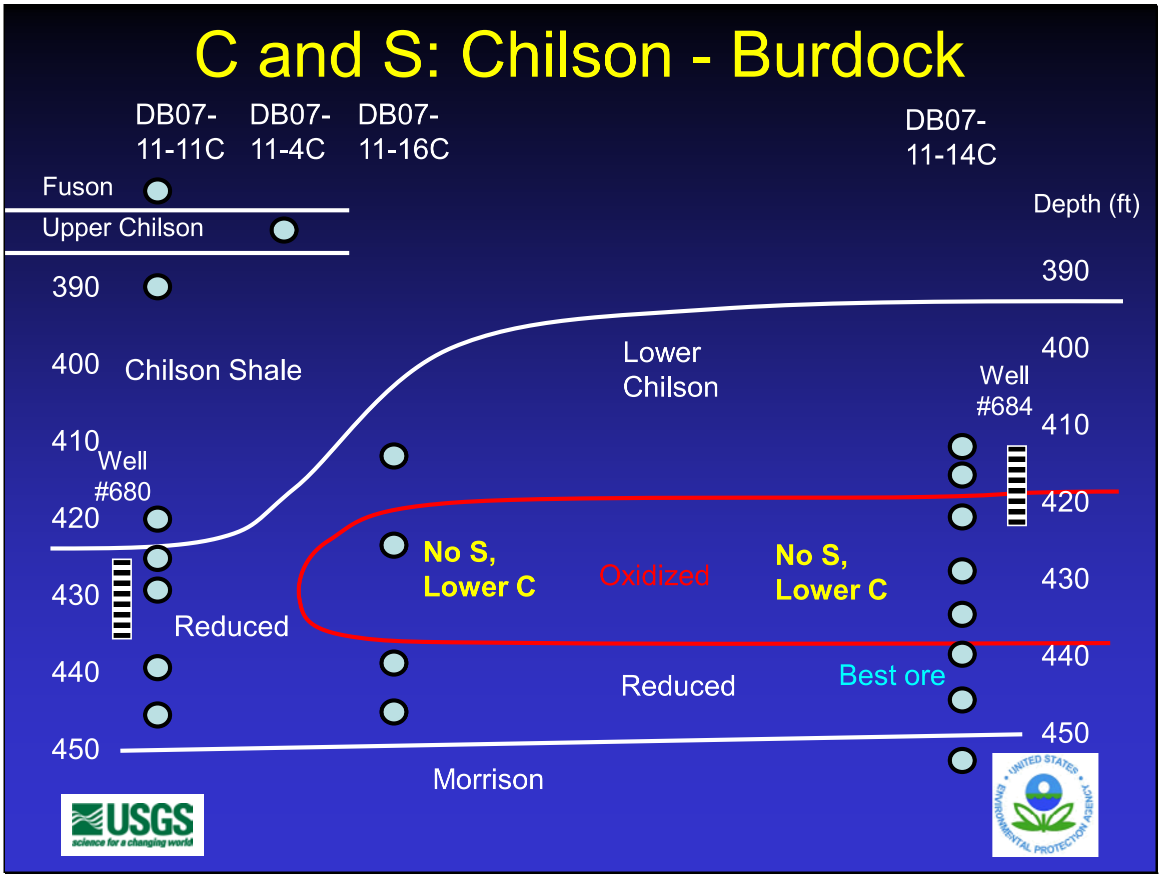


White box at well screen indicates uranium isotope value in groundwater.

Slide 25

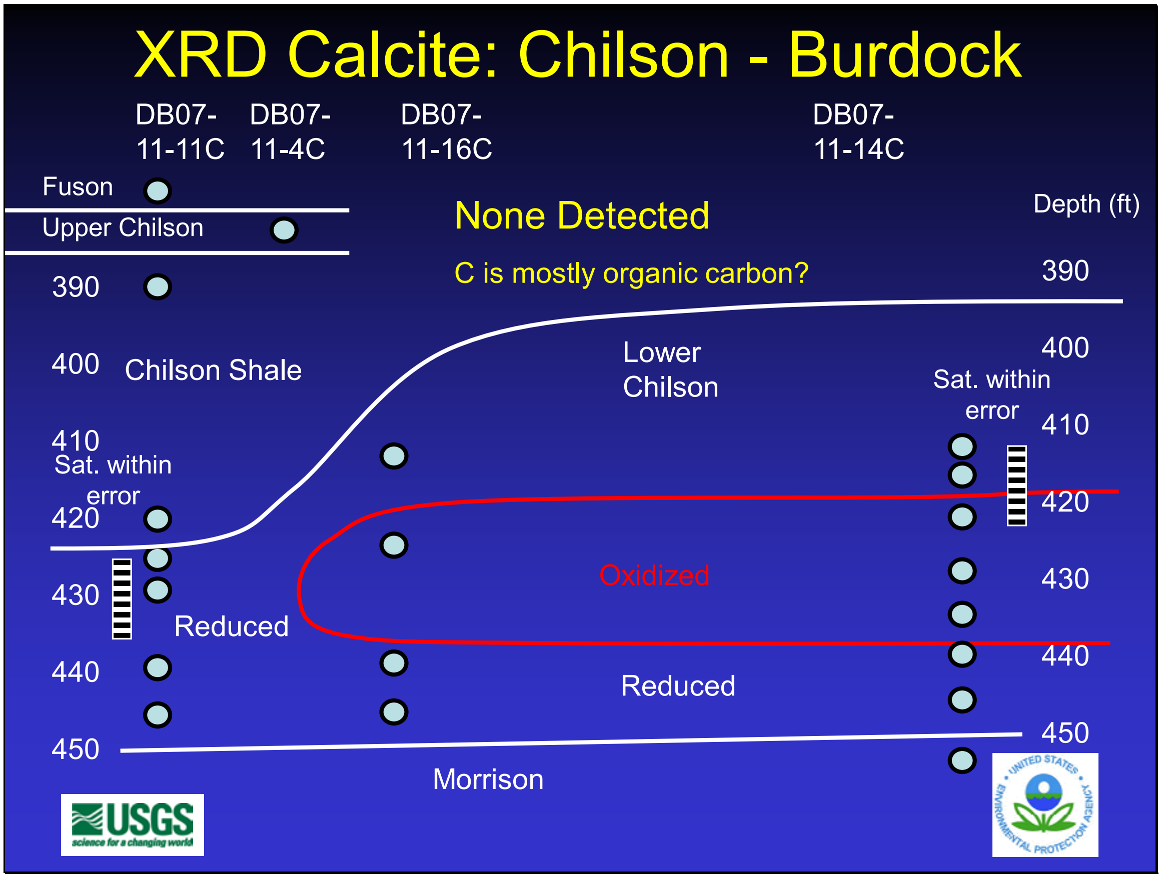


White box at well screen indicates dissolved organic carbon (DOC) value in groundwater.

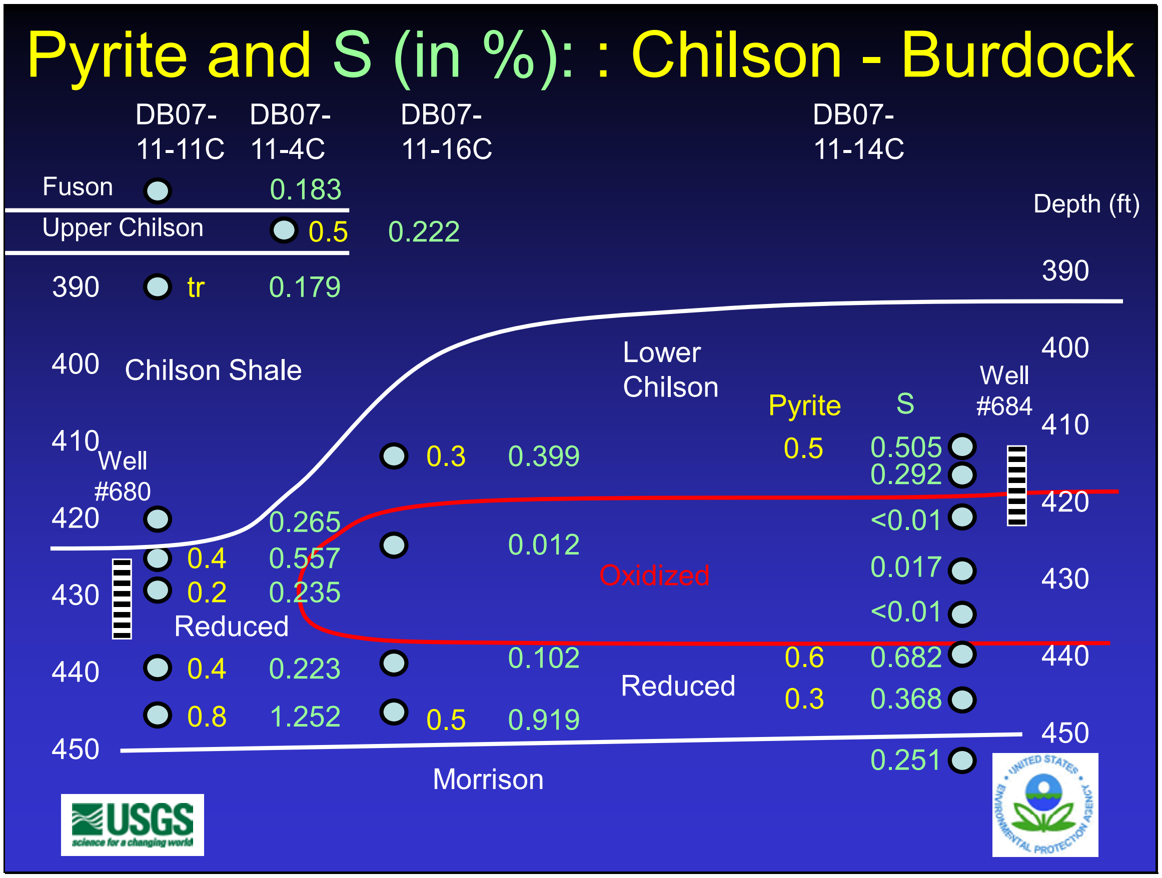


Simplified summary slide for C and S, with influence of oxidized zone.

Slide 27

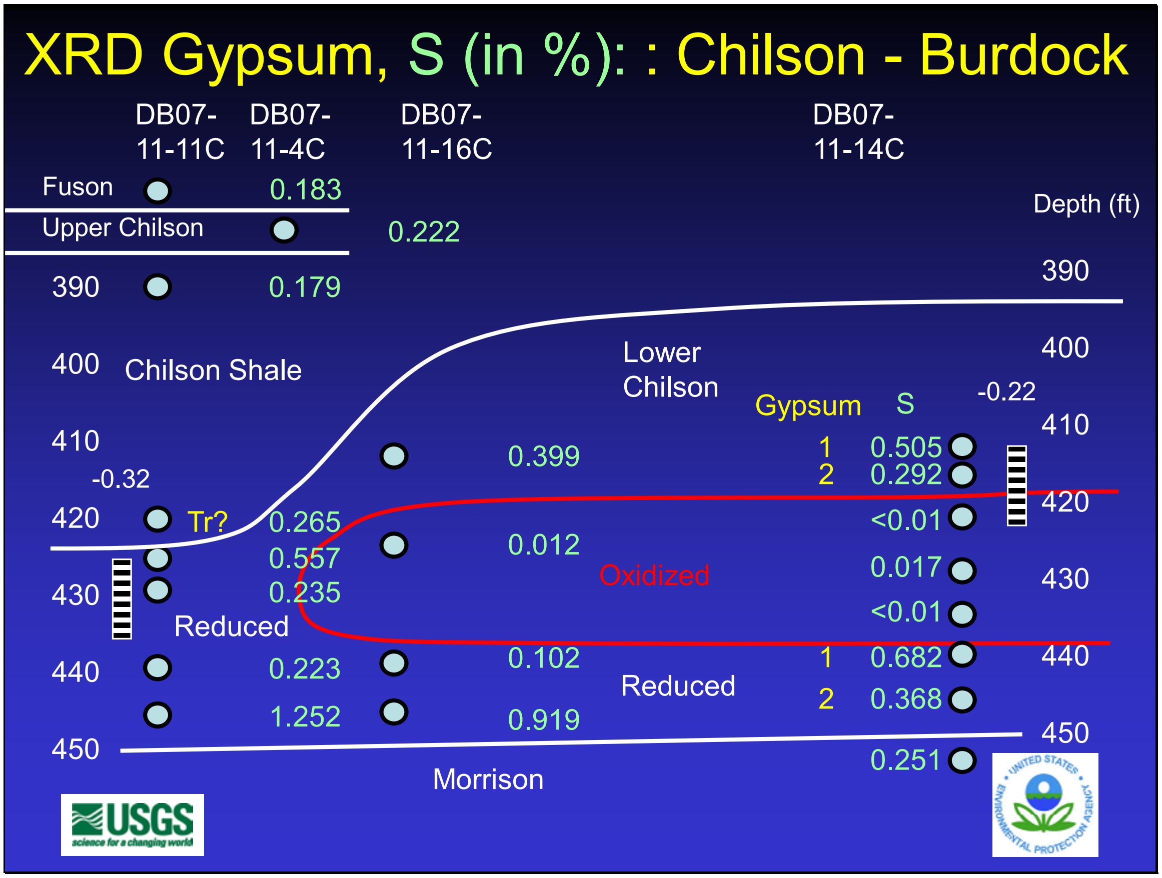


Sat. within error = analyses in these wells for calcite indicate fully saturated (i.e., in equilibrium), within analytical error.

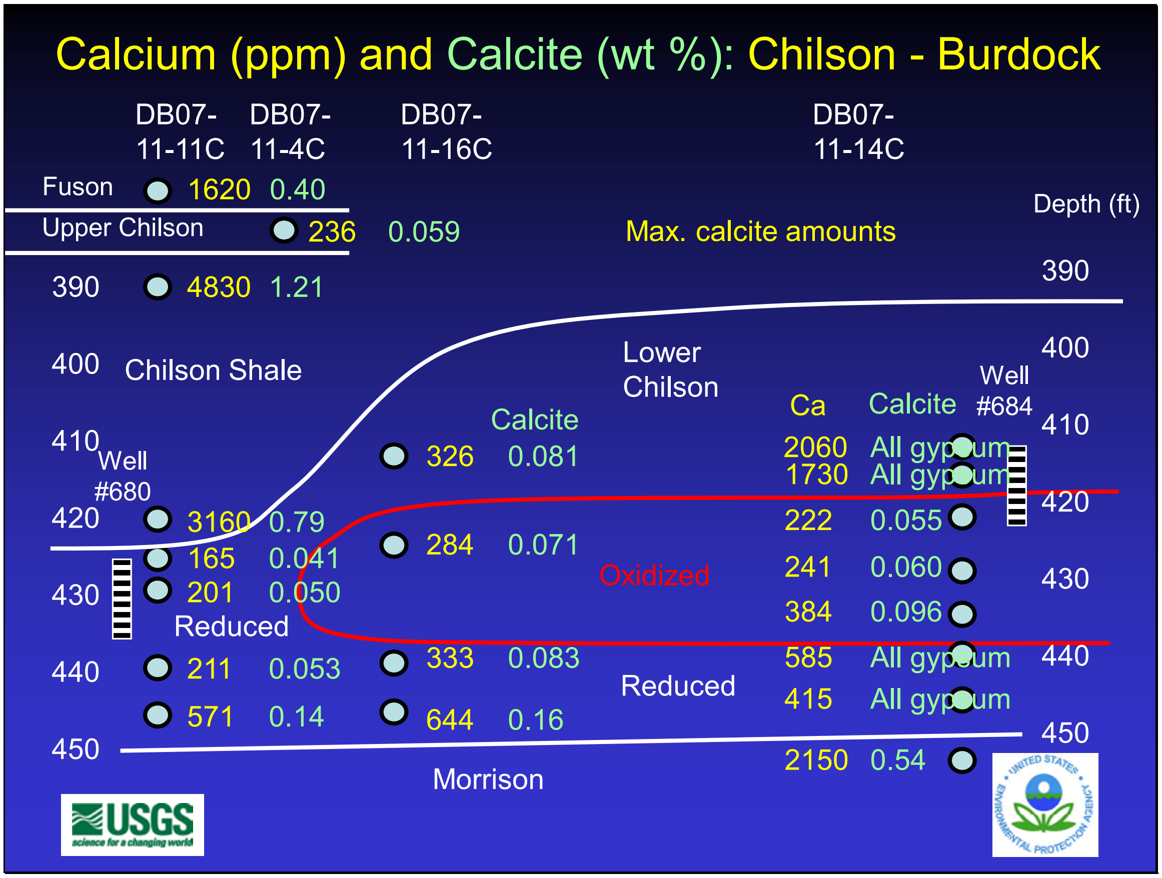


Much of the total sulfur amount can be attributed to pyrite and gypsum (next slide).

Slide 29



Much of the total sulfur amount can be attributed to pyrite (previous slide) and gypsum.



Calcite was not detected in XRD data above trace amounts. This slide shows calcium concentrations in the solid phase (whole rock data) and calculates the maximum calcite amount based on calcium concentration (whole rock data) minus calcium accounted for in gypsum (from XRD data).

Slide 31

Burdock Summary and Interpretations

- Many U isotope values are less than one and indicate ore zone depletion of uranium in the last 1-2 million years
  - Indicates “recent” oxygen contact – unlike Dewey
- Carbon content is mostly organic carbon with very little calcite
  - Key difference from Dewey
- Lower vanadium content
- Sulfur content accounted for by pyrite (around 0.5 wt. % in reduced zones) and some gypsum
- Key indicators of an oxidized zone
  - High vanadium/uranium ratio (vanadium oxides)
  - Very low sulfur content (pyrite oxidized to hematite)
  - Red color in cores (oxidized iron)

Slide 32

Overall Solid-Phase Geochemistry Summary and Interpretations

- No big surprises, so far
- Key indicators of an oxidized zone
  - High vanadium/uranium ratio in Burdock cores (vanadium oxides)
  - Very low sulfur content (pyrite oxidized to hematite)
  - Red color in cores (oxidized iron)
- All the data match up nicely: visual core logs, geophysical logs, and geochemical samples
- Good co-location of solid-phase and groundwater samples
- These data will be used in reactive transport modeling