Potential Uranium Source Rocks of the White River Group in Western Nebraska and South Dakota*

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Abstract

Recent studies of the paleosols of the White River Group are used to identify two potential source rocks for the uranium mineralization at the Crow Butte mine. Identifying source rocks has important implications for exploration of uranium in the western Nebraska and southwestern South Dakota region. The Crow Butte uranium deposit located near Crawford, Nebraska was discovered in the fall of 1980. In January 1981, the deposit was reported to contain at least 25,000,000 pounds of U_3O_8 at a grade of 0.25% U_3O_8. This deposit has produced over 14,000,000 of U_3O_8 since 1991. The original lease position was acquired based on a favorable review of the regional geology indicating an extensive fluvial system underlying potential source rocks of the White River Group. In the last 30 years, detailed stratigraphic research has further refined our understanding of the paleosols and the paleohydrogeology of these volcaniclastic sediments. It is now possible for additional geochemical research to identify which paleosol acted as the source of the uranium.

The weakest link in the past exploration model for sandstone uranium deposits was the inability to recognize potential uranium source rocks. Based on the work of the Texas Bureau of Economic Geology in the 1970's and early 1980's, a functional uranium source rock should be a well developed paleosol where a large quantity of rhyolitic ash fall glass has been altered to clay (typically montmorillonite or kaolinite) under oxidizing conditions in the vadose zone. Reviewing the past 30 years of research in the paleopedology and paleohydrogeology of the White River Group, only two stratigraphic units can be considered potential source rocks. The two units are the Interior Paleosol Equivalent found at the top of the Chamberlain Pass Formation, and the Peanut Peak Member of the Chadron Formation. If the Interior Paleosol Equivalent is the functional source rock, then only the Chamberlain Pass Formation sandstones in Nebraska and Wyoming are of interest to the uranium exploration geologist. If the Peanut Peak Member is the functional source rock, then the Ahearn Member of the Chadron Formation would also be an attractive exploration target. Whole rock analysis of thorium and uranium of the potential source rocks should be useful as an exploration tool.

References

Catuneanu, O., 2006, Principles of Sequence Stratigraphy: Elsevier, Amsterdam, The Netherlands, 375 p.

Gjelsteen, T.W., and S.P. Collings, 1988, Relationship between ground water flow and uranium mineralization in the Chadron Formation, northwest Nebraska: Wyoming Geological Association Guidebook, Thirty-ninth Field Conference, p. 271-284.

Larson, E.E., and E. Evanoff, 1998. Tephrostratigraphy and source of the tuffs of the White River sequence, *in* D.O. Terry, H.E. LaGarry, and R.M. Hunt, (eds.), Depositional Environments, Lithostratigraphy, and Biostratigraphy of the White River and Arikaree Groups (Late Eocene to Early Miocene, North America): Geological Society of America Special Paper, v. 325, p. 1-14.

Rackley, R., 1972, Environment of Wyoming Tertiary Uranium Deposits: AAPG Bulletin, v. 56/4, p. 755-774.

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Why Study White River Group Paleosols as Possible Uranium Source?

- Crow Butte ISR Mine
- Zielinski USGS – Significant Source Of U
- Paleosols – U Source Rocks in Texas
- Revised Stratigraphy
- Chamberlain Pass Formation - CPF

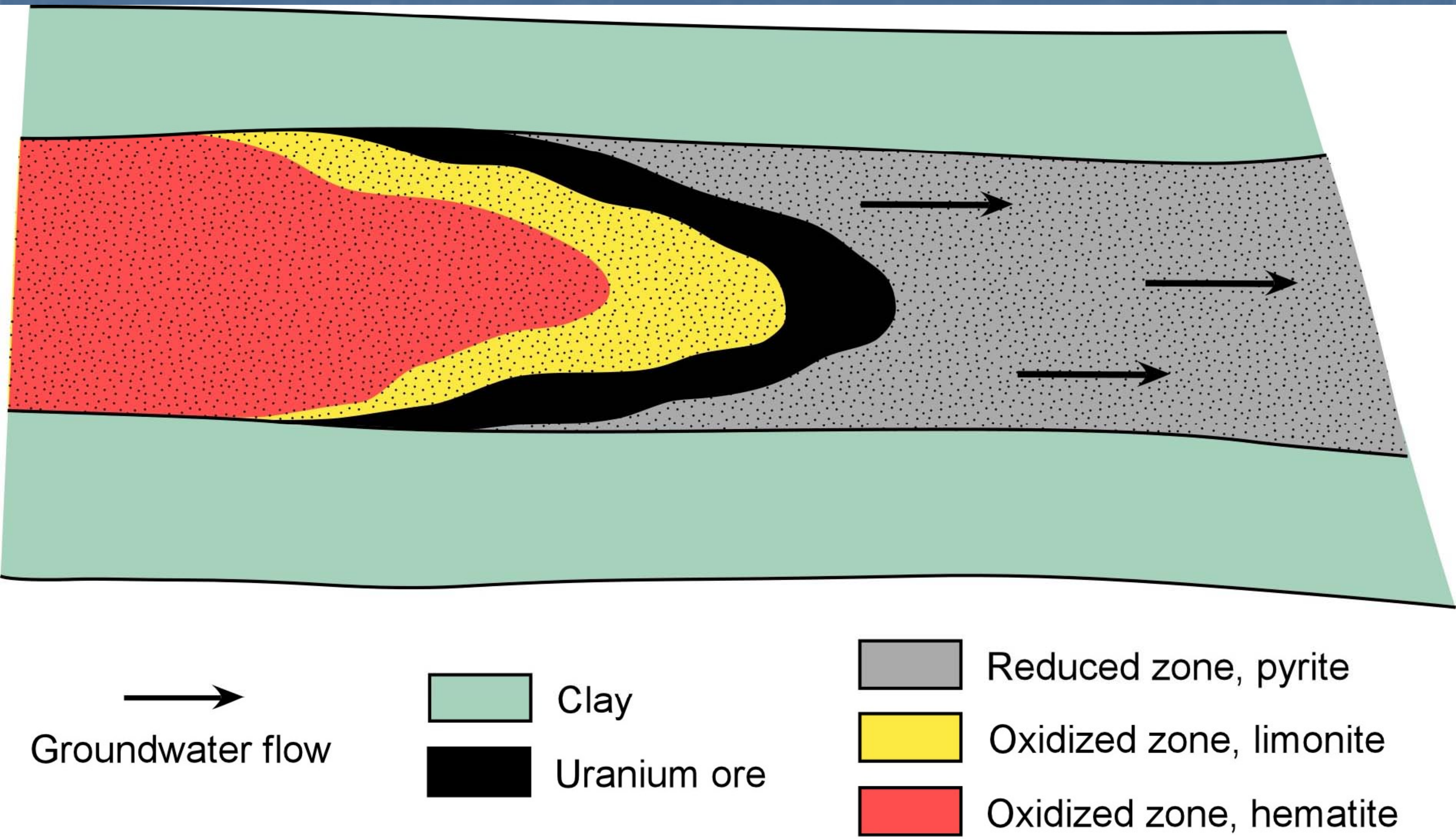
White River Group
Badlands National Park

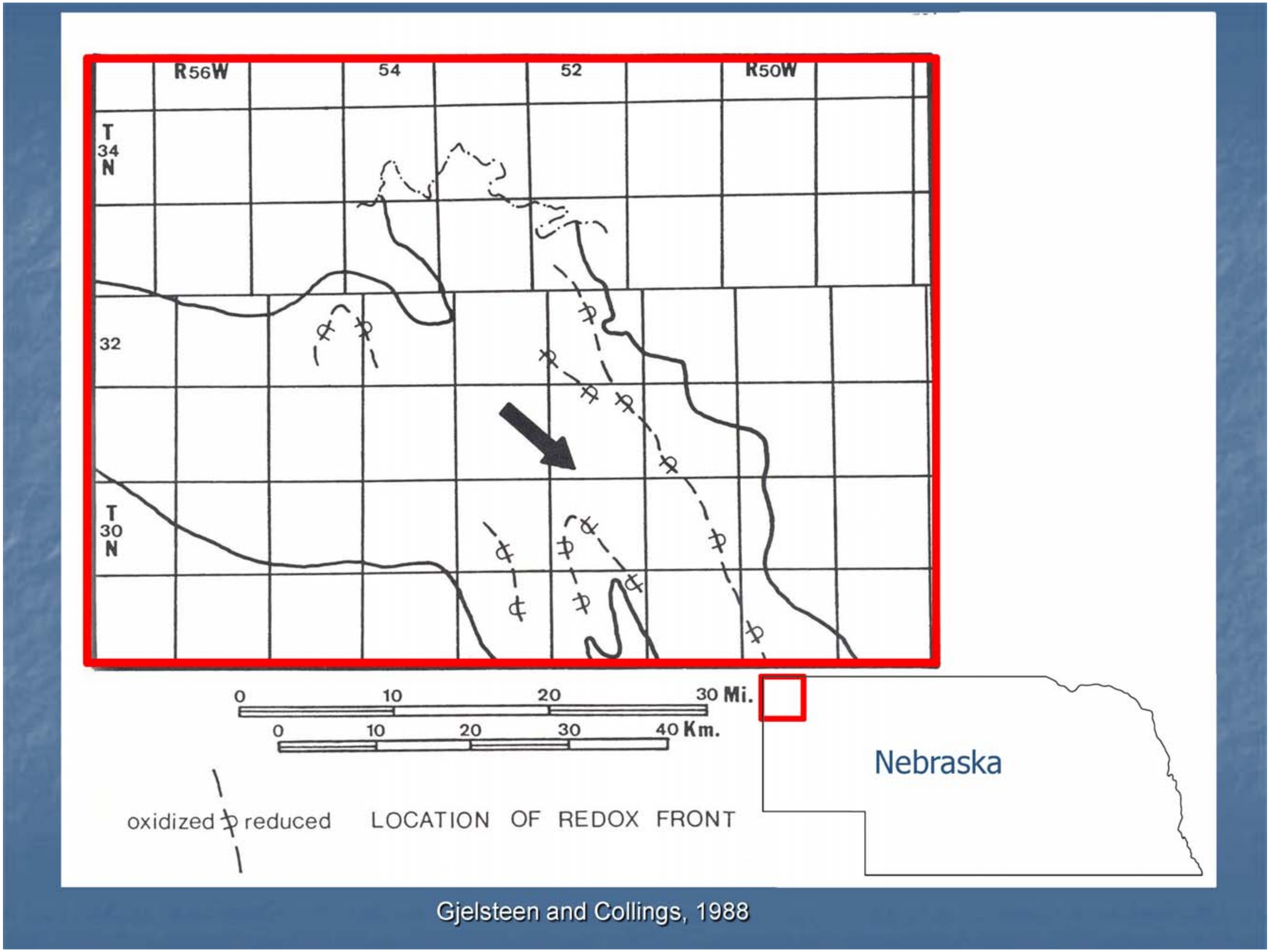

90
SOUTH DAKOTA
Rapid City
90
WY
SD
NE
CO
Paleo
Red River
Valley
Badlands
National Park
WYOMING
Whitehead
Creek
Chadron
Crawford
Crow Butte
Deposit
25
NEBRASKA
Scottsbluff
North Platte
Cheyenne
80
80
COLORADO
76


I 627

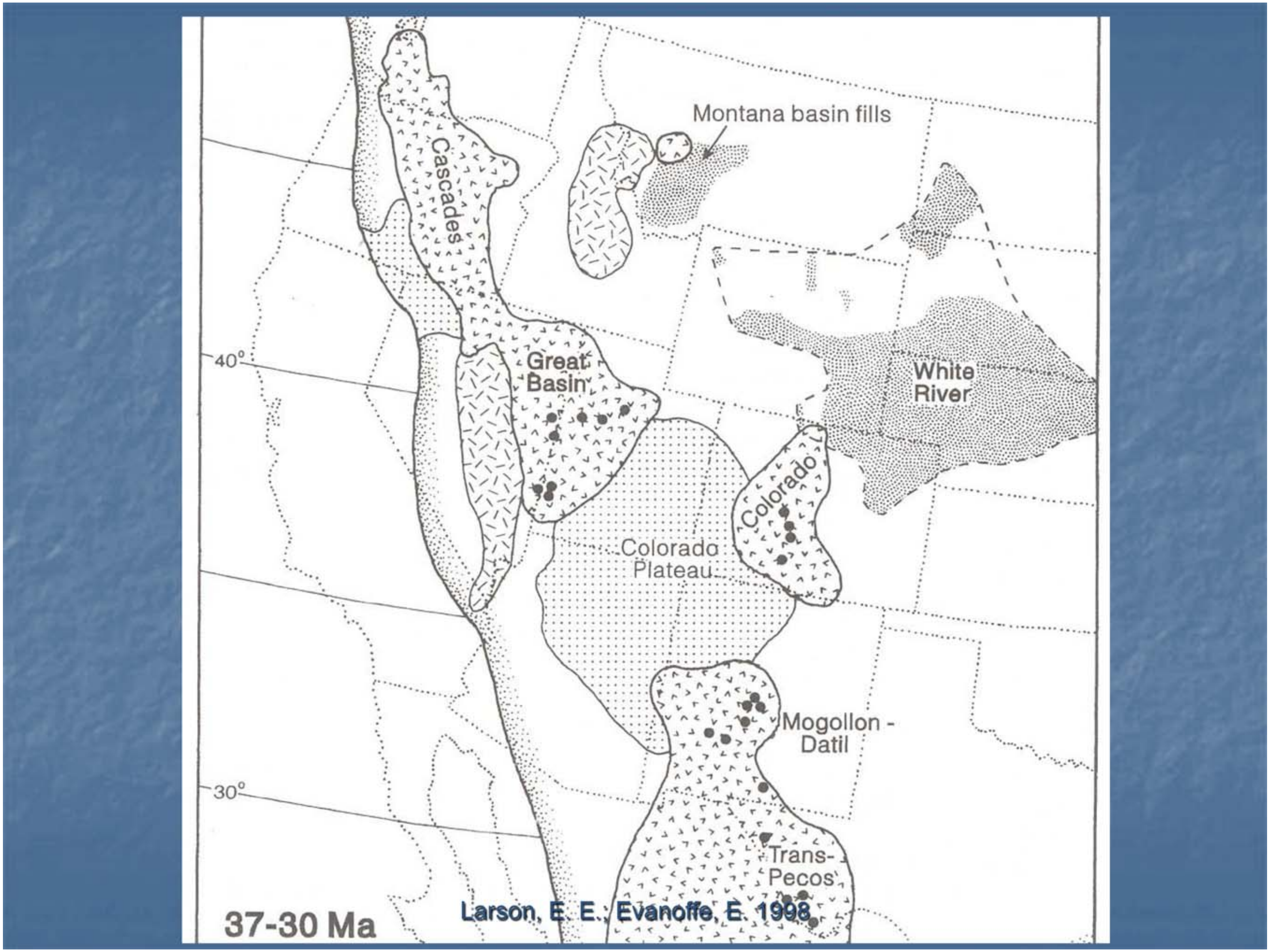
Crow Butte Deposit

- Discovery Announced – January 13, 1981
- $U_3O_8 \geq 25$ Million Lbs. $\geq 0.25\%$
- Production – Started 1991
- Produces ≈ 800,000 Lbs./Year
- Total Production = 15 Million Lbs.

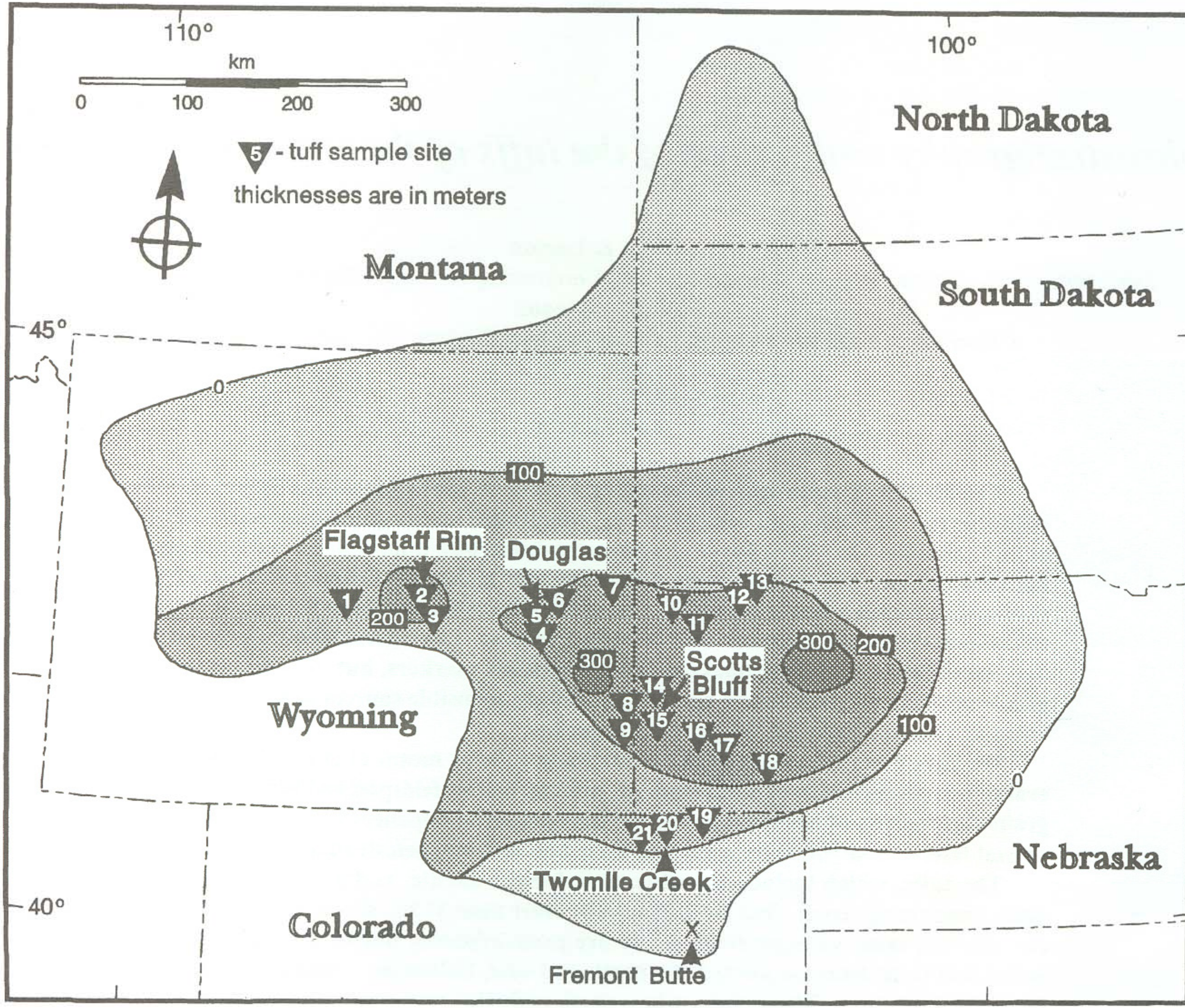

Groundwater flow
Clay
Uranium ore
Reduced zone, pyrite
Oxidized zone, limonite
Oxidized zone, hematite



Notes by Presenter: Roll front mineralization trends NW-SE, main ore body is 6 miles long and ¼ mile wide, groundwater flow direction to SE during mineralization. Gjelsteen and Collings, 1988 WGA Guidebook.



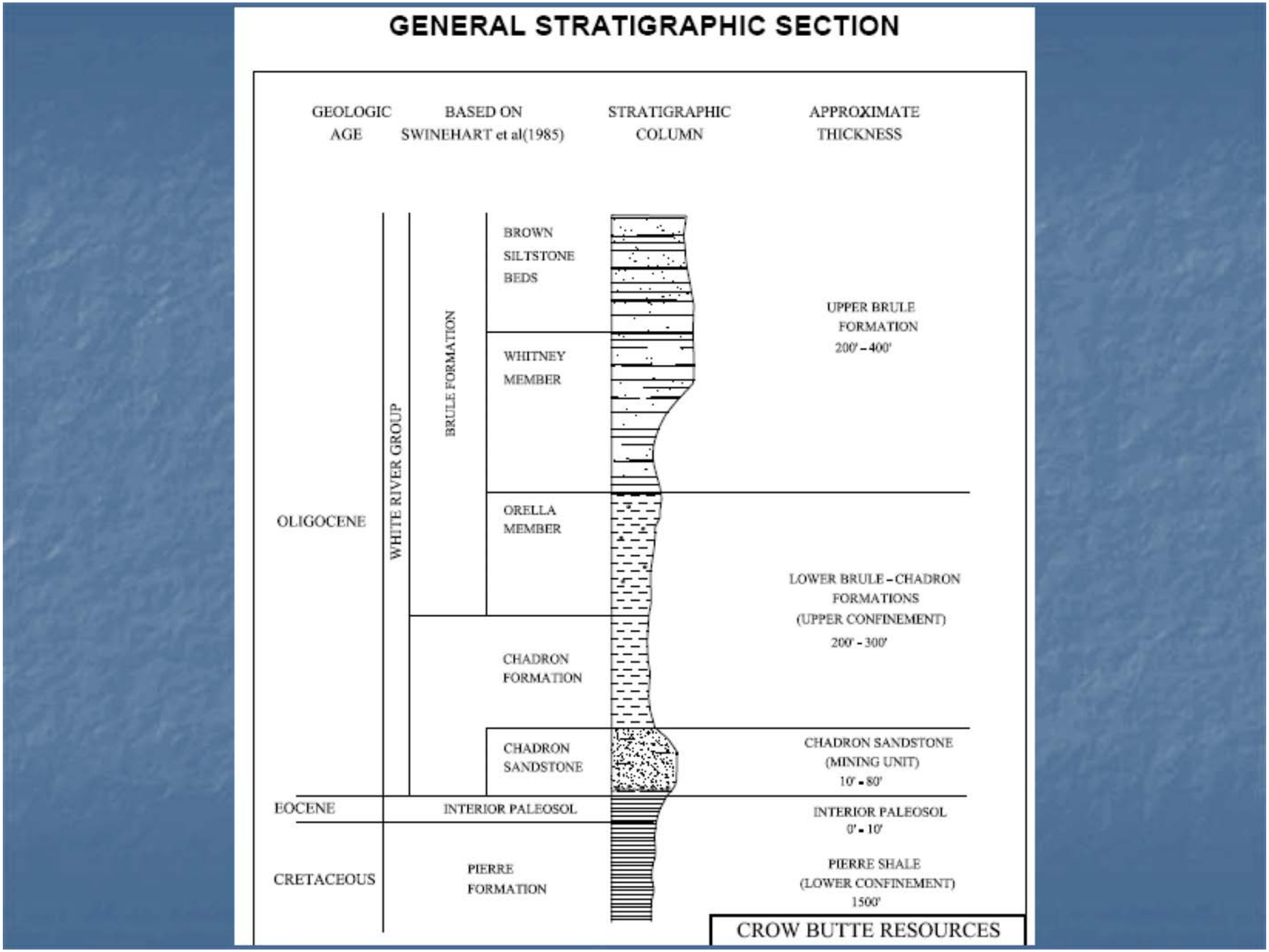
Notes by Presenter: Source of the tuffaceous material in the White River Group is from volcanic calderas in the Great Basin. Larson & Evanoff 1998, GSA Special Paper 325



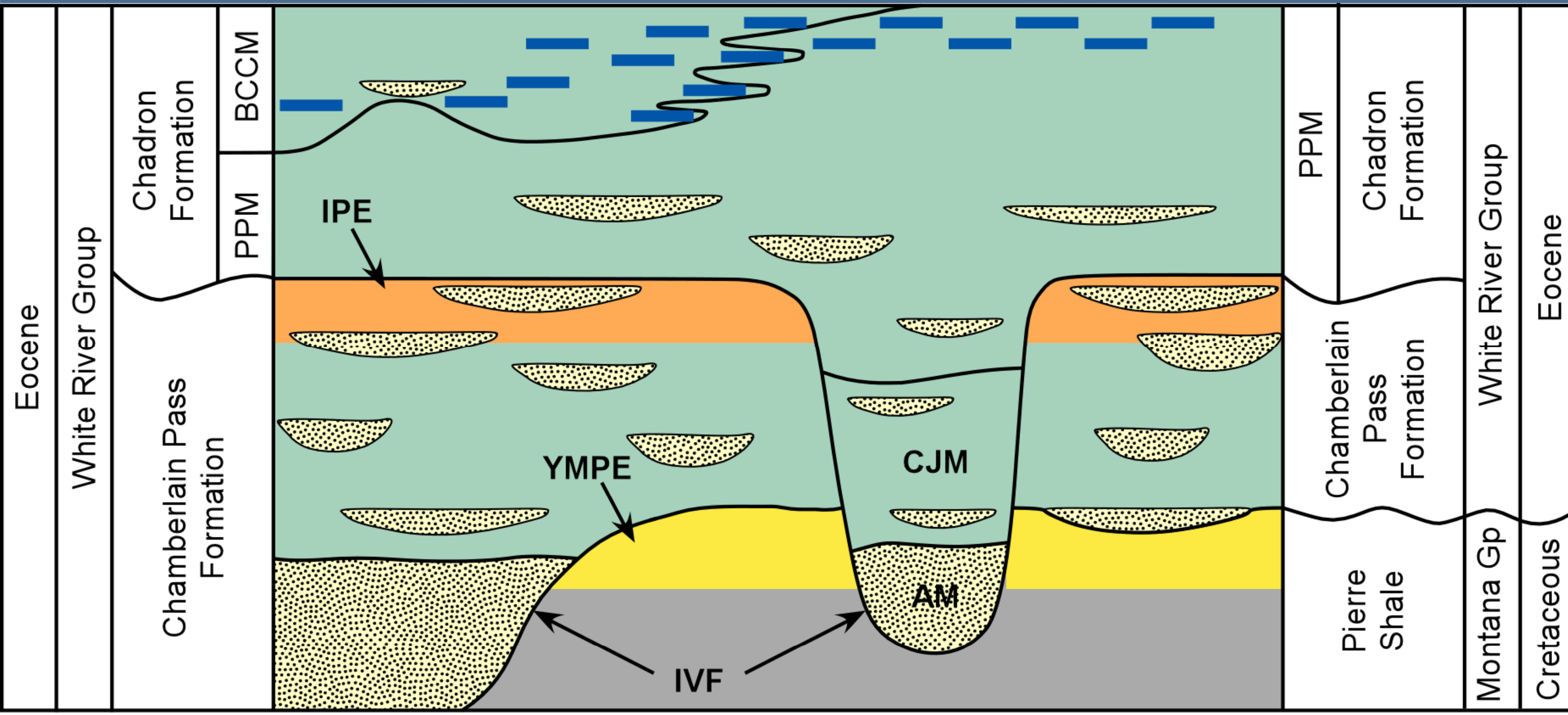
110°
100°
km
0
100
200
300
5 - tuff sample site
thicknesses are in meters
North Dakota
Montana
South Dakota
45°
0
100
Flagstaff Rim
Douglas
1
2
3
200
4
5
6
7
10
11
12
13
300
200
300
Scotts
Bluff
14
8
9
15
16
17
18
100
Wyoming
0
19
20
21
Twomile Creek
Nebraska
40°
Colorado
Fremont Butte

Source Of Uranium

Volcanic Glass + H_2O = Clay + SiO_2 + U^{+6} (in solution)



Notes by Presenter: 12Older interpretation of White River Group Stratigraphy.



Lacustrine limestone

Sand

Mudstone

Shale

Interior Paleosol Equivalent

Yellow Mounds Paleosol Equivalent

BCCM - Big Cottonwood Creek Member

PPM - Peanut Peak Member

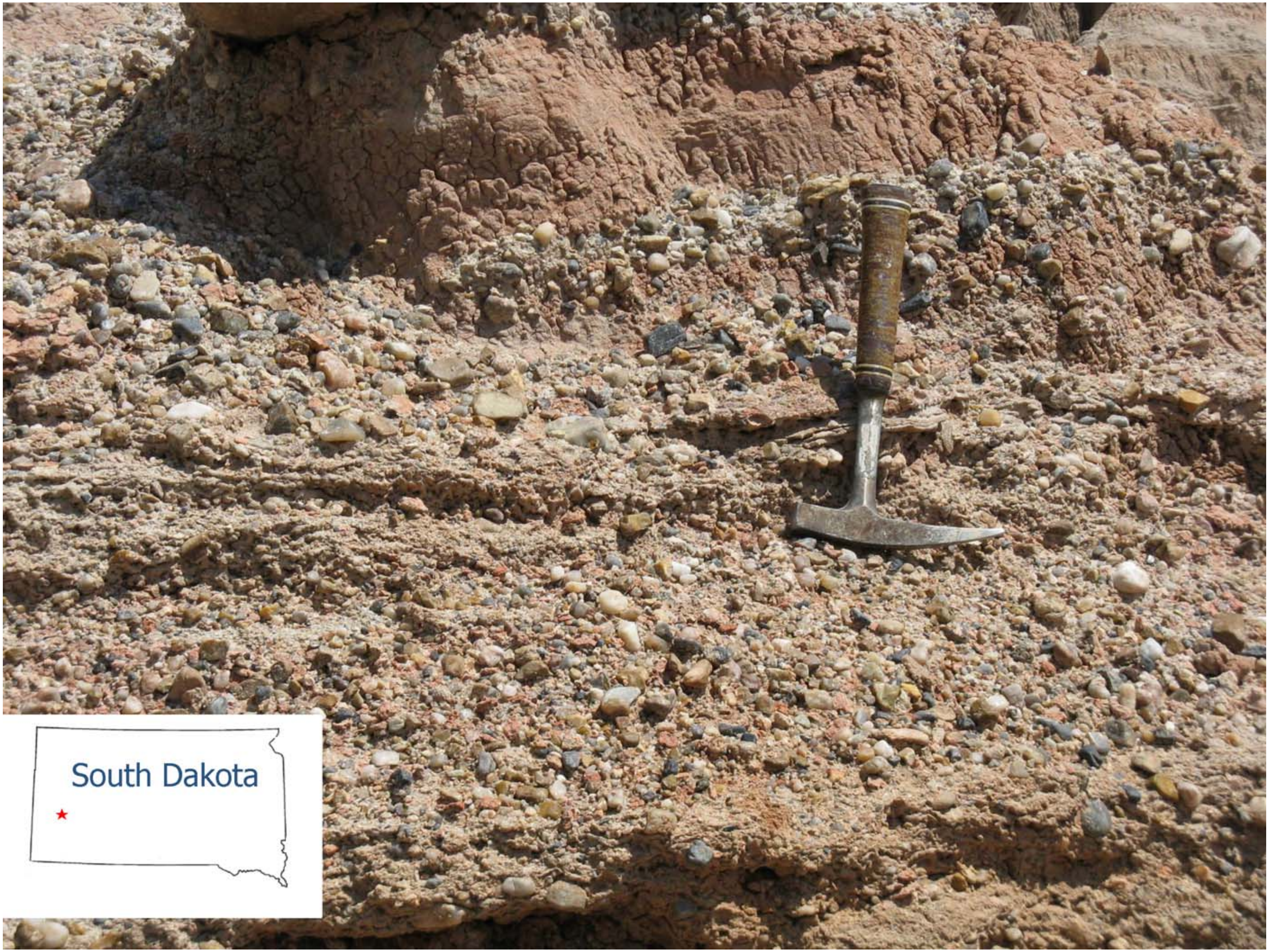
CJM - Crazy Johnson Member

AM - Ahearn Member

IPE - Interior Paleosol Equivalent

IVF - Incised Valley Fill

YMPE - Yellow Mounds Paleosol Equivalent



Notes by Presenter: Arkosic basal sand of theAhearn Member of Chadron Formation near Red Shirt, South Dakota.

Notes by Presenter: Basal Sand of Chamberlain Pass Formation – Whitehead Creek, Nebraska

Notes by Presenter: Outcrop of Chamberlain Pass Formation sandstone overlain by Peanut Peak member of Chadron Formation. Noticed the “bleached” appearance of the sandstone.

Comparison between sequence-bounding paleosols and the paleosols developed within sequences.

Paleosol type / Features	Sequence-bounding paleosols	Paleosols within sequences
maturity	strongly developed	weakly to well-developed
soil saturation	well-drained	wetter
hiatus	10^4 yr or more	0-10^3 yr

Modified from: Catuneanu, O. 2006. Principles of Sequence Stratigraphy. Elsevier, Amsterdam, The Netherlands. pg. 30.

“Following burial, **uplift-induced changes in the hydrodynamic system caused an invasion of the reduced sediment** by oxygenated water far below the static water table.”

Rackley, R. AAPG Bulletin 1972, p 755

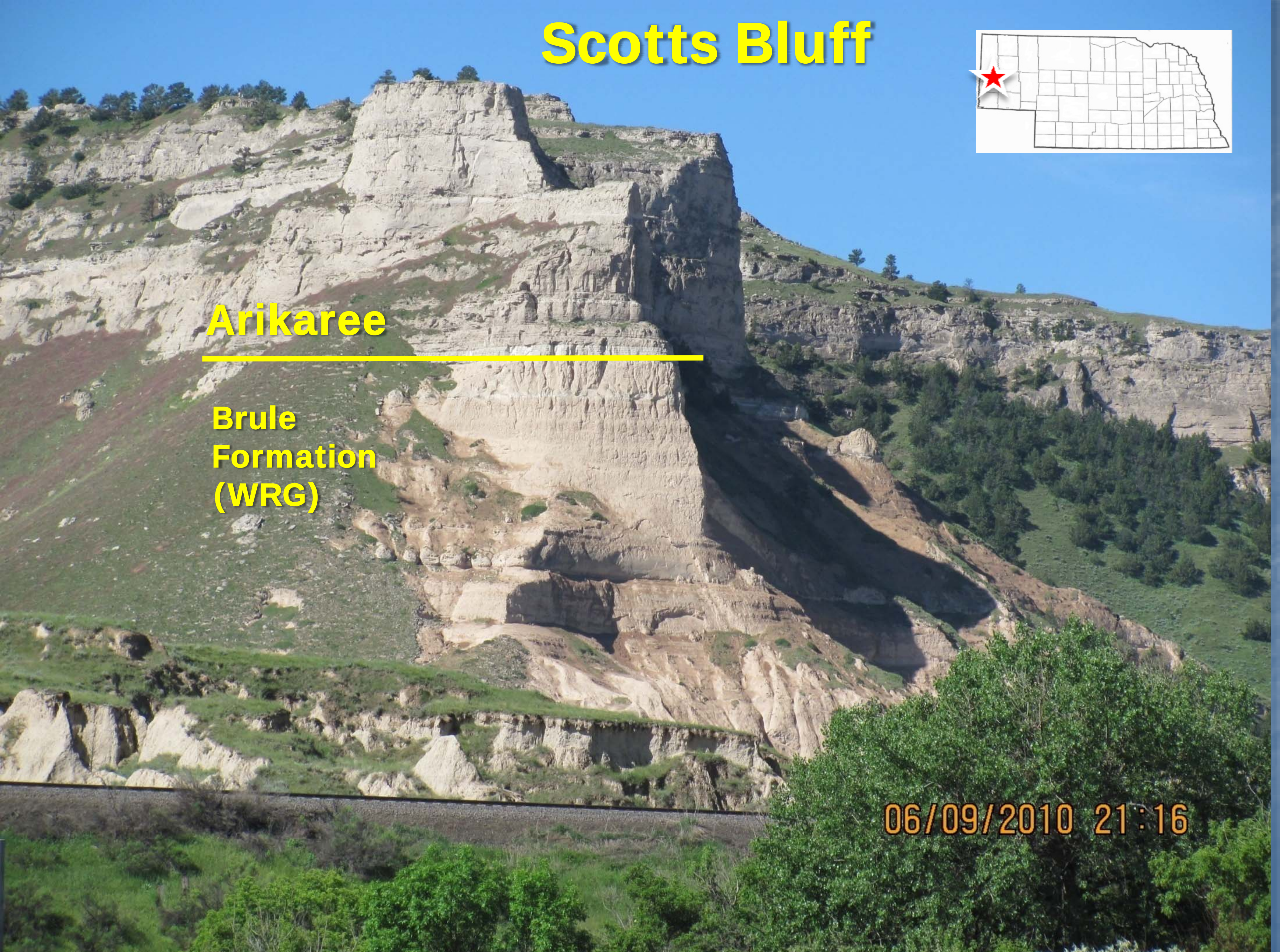
If Uplift is the Driving Force for the Development of Roll Front Deposits, Is This Expressed in The Sedimentary Record?

Sequence Bounding Paleosols?

Unconformidities?

Th/U Ratios

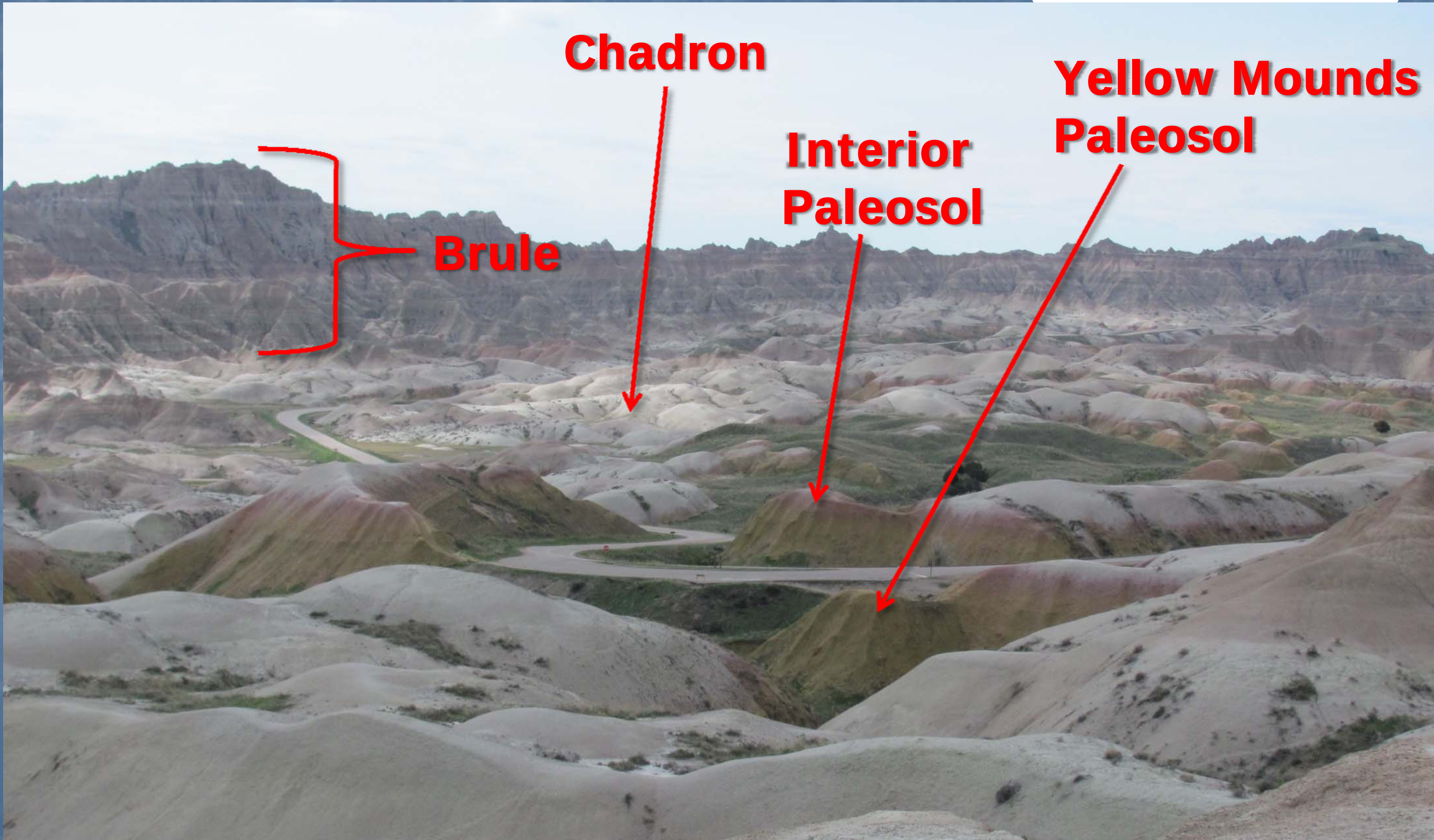
- Zielinski – USGS – 1970's
- Th and U Behave Similarly in Magma
- Th/U Ratios Relatively Constant – Volcanic Source
- Th – Not Mobile During Weathering
- Th/U – Higher In "Source" Rock
- WRG Siltstone Loss Of 0.4 ppm ± 0.4ppm U


Scotts Bluff
Arikaree
Brule
Formation
(WRG)
06/09/2010 21:16

Interior Paleosol – Uranium Source?

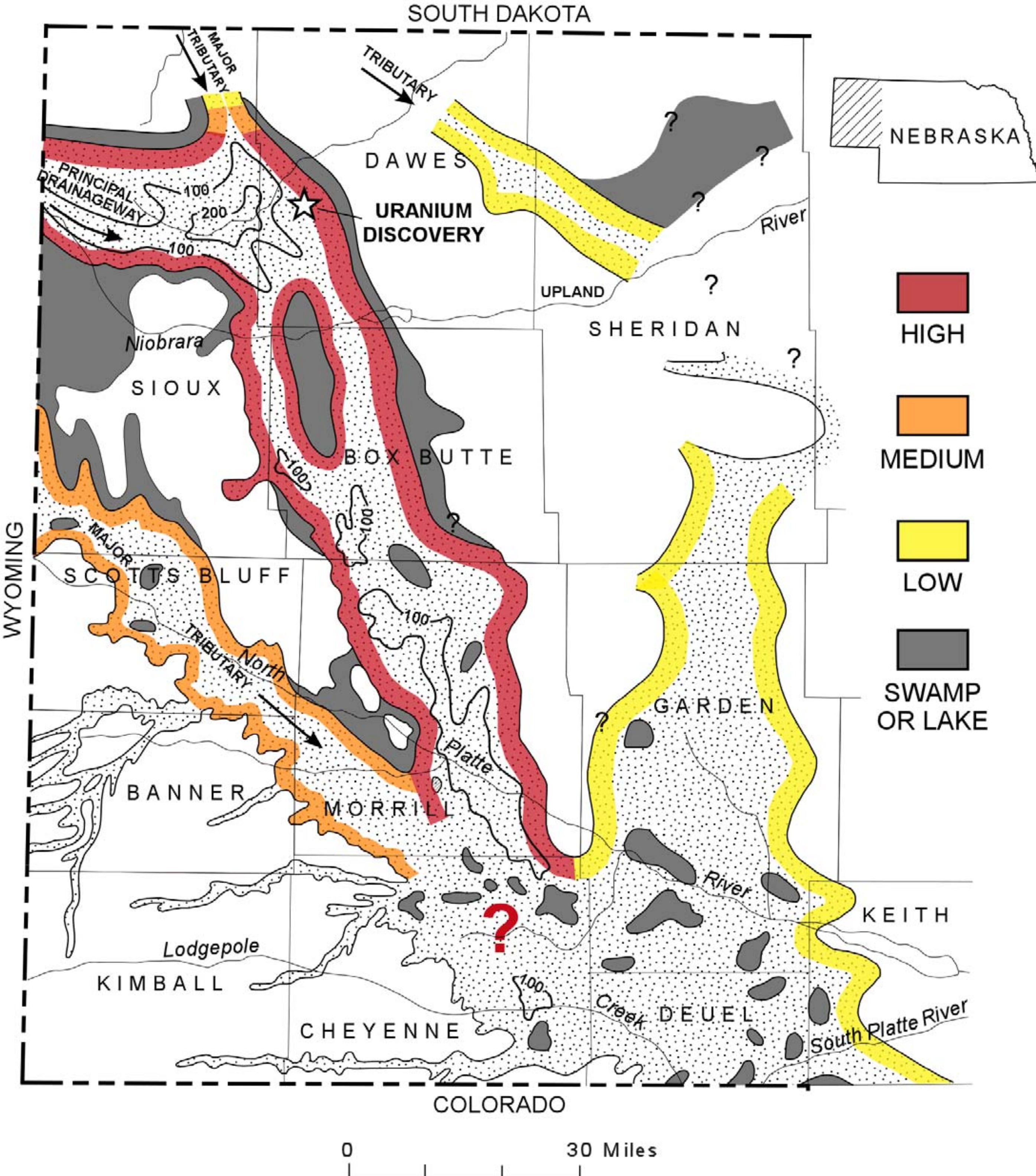
- Long Period Of Time To Develop
- Lower Water Table
- Leach Large Areas/Volumes
- Higher Hydraulic Gradient – Greater GW Flow
- Requires Tuffaceous Parent Material
- Tuffaceous Questionable in SD

White River Group
Badlands National Park

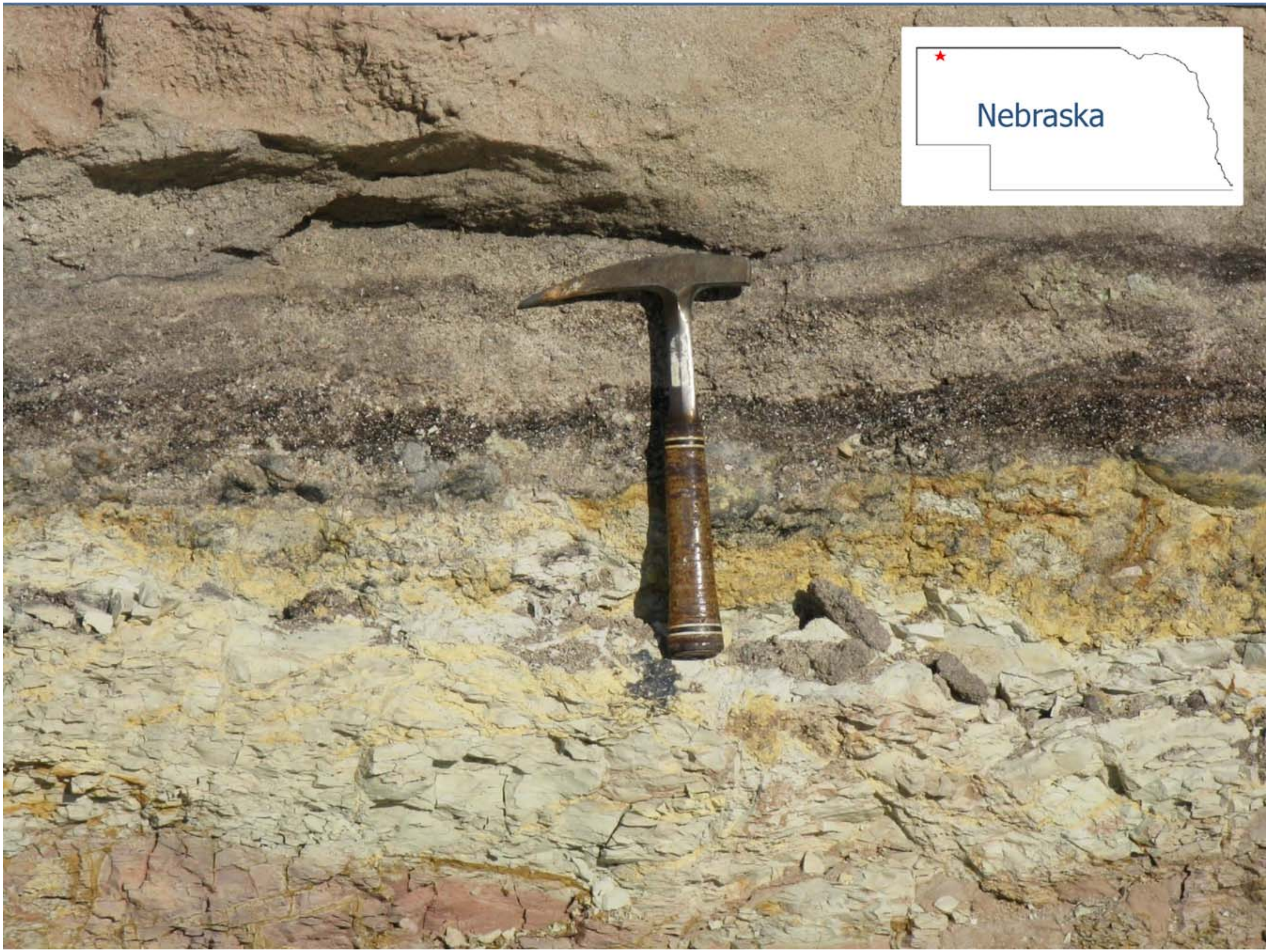


Chadron Mudstones – Uranium Source?

- Paleosols – Less Developed-
- Higher Water Table- Less Leaching
- Fate Of Uranium Leached ?
- Lake and Spring Deposits [BCCM]
- Groundwater Discharge Zone [BCCM]
- Calcrete Type Mineralization [BCCM]
- PPM – Possible Source, BCCM – Very Unlikely



SOUTH DAKOTA
COLORADO
WYOMING
NEBRASKA
MAJOR TRIBUTARY
TRIBUTARY
PRINCIPAL DRAINAGEWAY
URANIUM DISCOVERY
DAWES
SHERIDAN
SIOUX
BOX BUTTE
SCOTTS BLUFF
GARDEN
BANNER
MORRILL
KIMBALL
CHEYENNE
DEUEL
KEITH
UPLAND
River
Niobrara
North
Platte
River
Lodgepole
Creek
South Platte River
MAJOR
TRIBUTARY
100
200
HIGH
MEDIUM
LOW
SWAMP OR LAKE
0
30 Miles

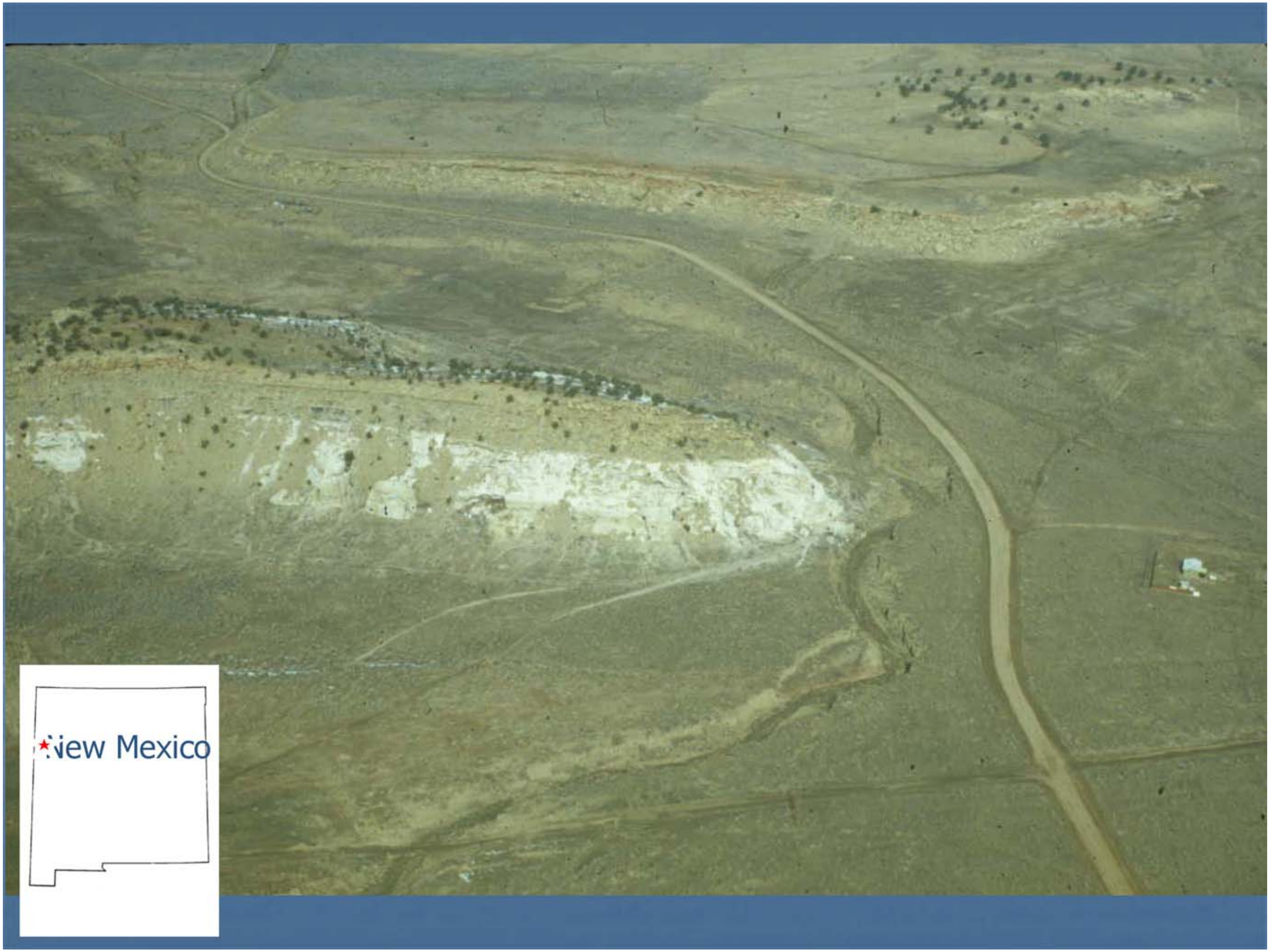


Notes by Presenter: 26Carbonaceous material and Mn oxides in basal CPF at Whitehead Creek, Nebraska. No uranium minerals present. Why? It is possible that oxidizing solutions formed during the formation of Interior Paleosol were low in uranium, parent material may have been the weathered Yellow Mounds paleosol – see next slide.

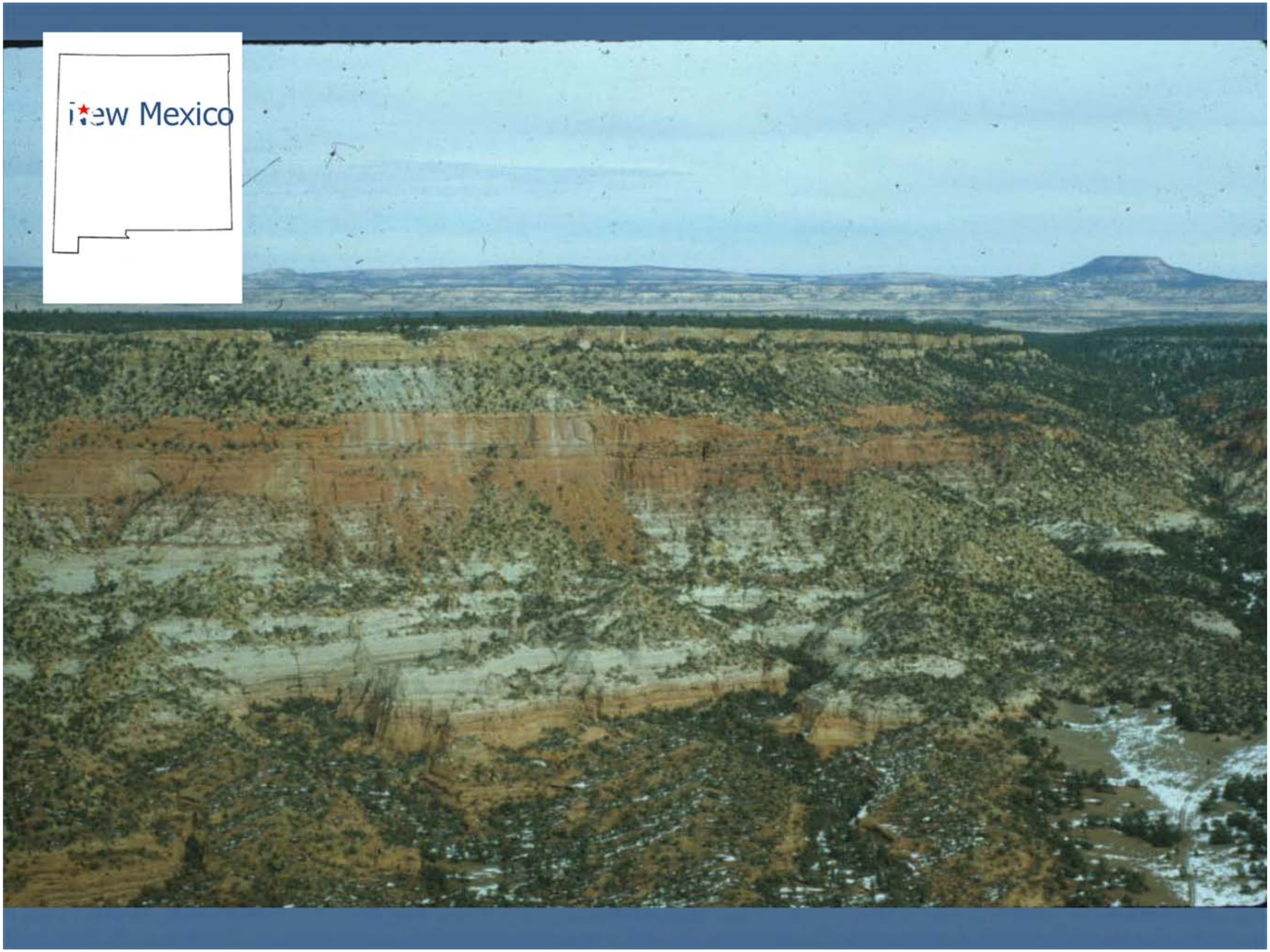
Conclusions

- Brule Formation Paleosols – Unlikely U Source
- IPE and PPM Paleosols - Possible Uranium Sources
- If PPM U Source - Ahearn in SD Viable Target
- Study of Paleosols Key to Understanding U Source
- Use High Th/U to Identify U Source Rocks
- Reconstructing Paleohydrogeology – Migration Path
- Margins of IVF – "Uranium Traps"

Questions???



Notes by Presenter: Cretaceous Dakota Formation unconformably overlying "bleached" Westwater Canyon member of Jurassic Morrison Formation near Church Rock [Gallup area], NM.



Notes by Presenter: Cretaceous Dakota Formtion uncomformably overlying Jurassic Morrison Formation, Grants Mineral Belt. Brushy Basin Member, mostly covered slope, Westwater Canyon Member shows iron oxide staining.