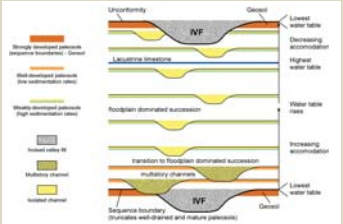
INT-059

Hydrostratigraphic Controls on Uranium Mineralization – Example: The Nebraska Panhandle

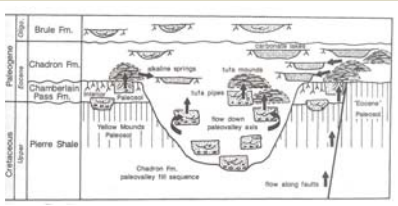
Click To View Abstract

Steven S. Sibray and Marvin P. Carlson
Nebraska Geological Survey *University of Nebraska–Lincoln*

HYDROSTRATIGRAPHY AND MINERALIZATION



Paleosol development in different stages of fluvial accommodation. Sequence bounding paleosols [geosols] developed over a significant period of time and are associated with significant drops in the water table. The Interior Paleosol is a widespread sequence bounding paleosol or geosol while the paleosols of the Chadron Formation are less well developed. [modified from Catuneanu, 2006]



Paleogroundwater deposits [mostly carbonates] indicate that groundwater flow direction was predominantly upward during Chadron Formation deposition [from Evans and Welzenbach 1998] Leaching of uranium while groundwater was flowing upward may result in the weak uranium mineralizationin the calcareous mudstones noted by Dickinson 1990.

Photo courtesy of J.E.Evans

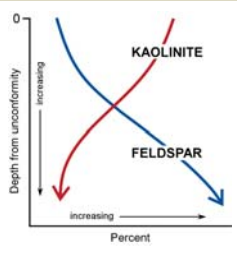
Tufa [nonpedogenic calcrete pinnacle] demonstrates groundwater flow was upward during carbonate deposition.

Interior Paleosol or Chadron Paleosol Series –

Which is the Source of Uranium?

The Interior Paleosol developed over a significant period of time and is associated with a significant drop in the water table which would expose previously deposited tuffaceous sediments to leaching in the vadose zone. In contrast, the Chadron Formation paleosols are less well developed and there was a higher water table. Th/U ratios might be useful in determining which paleosols are depleted in uranium with respect to thorium. However, this might not tell us the fate of the uranium leached. Reconstructing the paleohydrogeology should be one of the criteria used when evaluating potential sources for uranium. If there is a high water table, any uranium leached may end up discharged into a stream or lake. In a low water table situation, any uranium leached is much more likely to end up in the underlying aquifer. It is for these reasons that the authors prefer the Interior Paleosol as a source for the uranium.

Chamberlain Pass Formation sand overlain by Peanut Peak Member of the Chadron Formation. Sand has been extensively weathered, feldspars have been altered to kaolinite and iron has been "bleached" or reduced prior to Chadron Formation deposition. Removal of iron oxides or reprecipitation of pyrite by reduction reactions can obscure the original oxidation event that formed the uranium roll front and make exploration difficult. The paleosols developed within the upper part of the Chamberlain Pass Formation show both oxidizing and reducing conditions (Terry and Evans, 1994). Methane, which is present locally, can also react and reduce iron oxides.



An inverse relationship between feldspar and kaolinite is seen in this type of weathering profile. "Bleaching" was caused by low pH and low pe water.

Sequence of Deposition and Mineralization and Implications for Exploration

1) Deposition of Chamberlain Pass Formation in local incised valleys.
2) Valleys fill and deposition becomes lower energy but widespread.
3) Local pyrite formation where carbonaceous material present – incised valley margins.
4) Tectonic uplift – shift from deposition to erosion and paleosol formation.
5) Development of Interior Paleosol and leaching of uranium, formation of roll front deposits.
6) Acidic and reducing weathering of Chamberlain Pass causes "bleaching".
7) Deposition of Chadron Formation, uranium is deposited in weakly mineralized evaporitic lacustrine mudstones due to a high water table.

The implications for explorations are as follows:

1) Permeable formations underlying the Interior Paleosol are possible exploration targets.
2) Iron minerals may not always be an effective exploration tool.
3) The Chamberlain Pass Formation is much more likely to host roll front deposits than the Chadron Formation.
4) Differentiation of the two sands is a critical factor in exploration.

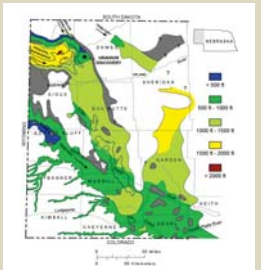
POTENTIAL URANIUM EXPLORATION TARGETS

Subcrop map of the geology underlying the White River Group in the Nebraska Panhandle. Permeable units are colored yellow. During the 1970's, Ferret Exploration found mineralization in the Fox Hills in Kimball Co. Union Carbide found mineralization in the Dakota Group on the Chadron Arch in Sheridan Co. Both units are dominantly marine sandstones and permeability could limit the feasibility of ISR mining. Map from Swinehart et al. 1985

Distribution of sands in the Chamberlain Pass Formation. Permeability of the Chamberlain sands and gravels are high and are very amenable to ISR mining. Highest potential for uranium roll front deposits is along the margins of the main valley entering Nebraska from Wyoming in northern Sioux Co. The major tributary entering Nebraska from Wyoming in southern Sioux Co. also has potential. The tributaries entering Nebraska from South Dakota are less attractive due to lack of mineralization seen in outcrop [see next photo]. Map from Swinehart et al. 1985

Carbonaceous material and Mn oxides at base of the Chamberlain Pass Formation. No uranium mineralization is present. This channel tributary is located near Whitehead Creek, Nebraska and flow direction is from north to south from South Dakota.

Outcrop of Interior Paleosol [red] developed directly on top of Yellow Mounds Paleosol [yellow] west of Whitehead Creek, Nebraska. The previously weathered Cretaceous shale would not make a good source rock for uranium. This is typical of the relationship between the two paleosols seen in the northern Panhandle of Nebraska and South Dakota. In contrast, the red Interior Paleosol overlies the green mudstones of the Chamberlain Pass Formation in the subsurface in Nebraska.



Depth to the base of the Chamberlain Pass Formation. Most of the areas with the potential for uranium mineralization are at relatively shallow depths.

SUMMARY

- Considering paleohydrogeology is an important step in evaluating uranium sources.
- The Interior Paleosol is the most likely source of uranium at Crow Butte.
- The best potential for uranium deposits is in the Chamberlain Pass Formation.
- The margins of the incised valleys entering from Wyoming have the best potential.
- Iron minerals may not always be an effective exploration tool due to "bleaching".
- High permeability of the Chamberlain Pass sands are ideal for ISR.

REFERENCES CITED

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

Clark, J. Beerbower, J.R., and Kietzke, 1967, Oligocene sedimentation, stratigraphy, paleoecology, and paleoclimatology in the Big Badlands of South Dakota: Field Museum of Natural History, Fieldiana Geology Memoirs, Vol.5, p. 158.

Dickinson, Ken, 1991, Uranium and diagenesis in evaporitic lacustrine mudstone of the Oligocene White River Group, Dawes County, Nebraska. U.S.G.S. Bulletin 1956.

Evans, J.E., 1996, Evidence for Late Eocene unroofing of the Black Hills Uplift: Geological Society of America Abstracts with Programs, vol.28, no 7, p. A373.

Evans, J.E. and Welzenbach, L.C., 1998, Episodes of carbonate deposition in a siliciclastic dominated fluvial sequence, Eocene-Oligocene White River Group, South Dakota and Nebraska in Geological Society of America Special Paper 325, Depositional Environments, Lithostratigraphy, and Arikaree Groups (Late Eocene to Early Miocene, North America).

Gjelsteen, T.W. and Collings, S.P., 1988, Relationship between groundwater flow and uranium mineralization in the Chadron Formation, Northwest Nebraska in Wyoming Geological Association Guidebook 1988, Eastern Powder River Basin Black Hills.

Larson, E.E, and Evanoff, E. 1998, Tephrostratigraphy and source of the tuffs of the White River sequence in Geological Society of America Special Paper 325, Depositional Environments, Lithostratigraphy, and Arikaree Groups (Late Eocene to Early Miocene, North America).

Swinehart, J.B., Souders, V.L., DeGraw, H.M., and Diffendal, R.F., Jr., 1985, Cenozoic paleogeography of Western Nebraska, in Flores, R.M., and Kaplan, S.eds., Cenozoic paleogeography of the West-Central United States, Special Publication, Rocky Mountain Section: Tulsa, Society of Economic Paleontologists and Mineralogists, p. 209-229.

Terry, D.O., 1998, Lithostratigraphic revision and correlation of the lower part of the White River Group, South Dakota to Nebraska in Geological Society of America Special Paper 325, Depositional Environments, Lithostratigraphy, and Arikaree Groups (Late Eocene to Early Miocene, North America).

Terry, D.O. and Evans, 1994, Pedogenesis and paleoclimatic implications of the Chamberlain Pass Formation, Basal White River Group, Badlands of South Dakota: Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 110, p. 197-215.

Zielinski, R.A., 1983, Tuffaceous sediments as source rocks for uranium: a case study of the White River Formation, Wyoming, Journal of Geochemical Exploration, Vol. 18, p. 285-306.

CONTACT INFORMATION

STEVEN S. SIBRAY
4502 Ave I
Scottsbluff, NE 69361
308-632-1382
ssibray1@unl.edu

MARVIN P. CARLSON
624 Hardin Hall
Lincoln NE 68583-0996
402-472-7549
mcarlson1@unl.edu