

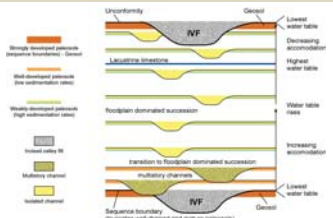
Hydrostratigraphic Controls on Uranium Mineralization – Example: The Nebraska Panhandle

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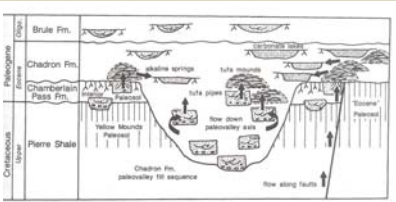
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HYDROSTRATIGRAPHY AND MINERALIZATION



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 Cataneau, 2006)



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

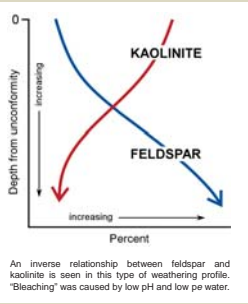
Interior Paleosol or Chadron Paleosol Series – Which is the Source of Uranium?

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.



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

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.



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



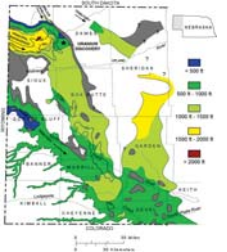
Subcrop map of the geology underlying the White River Group in the Nebraska Panhandle. Permeable units are colored yellow. During the 1970's, Ferret Exploration found mineralization in the Fox Hills in Kimball Co. Union Carbide found mineralization in the Dakota Group on the Chadron Arch in Sheridan 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.



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.

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