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Uranium Deposits in Southwestern North Dakota

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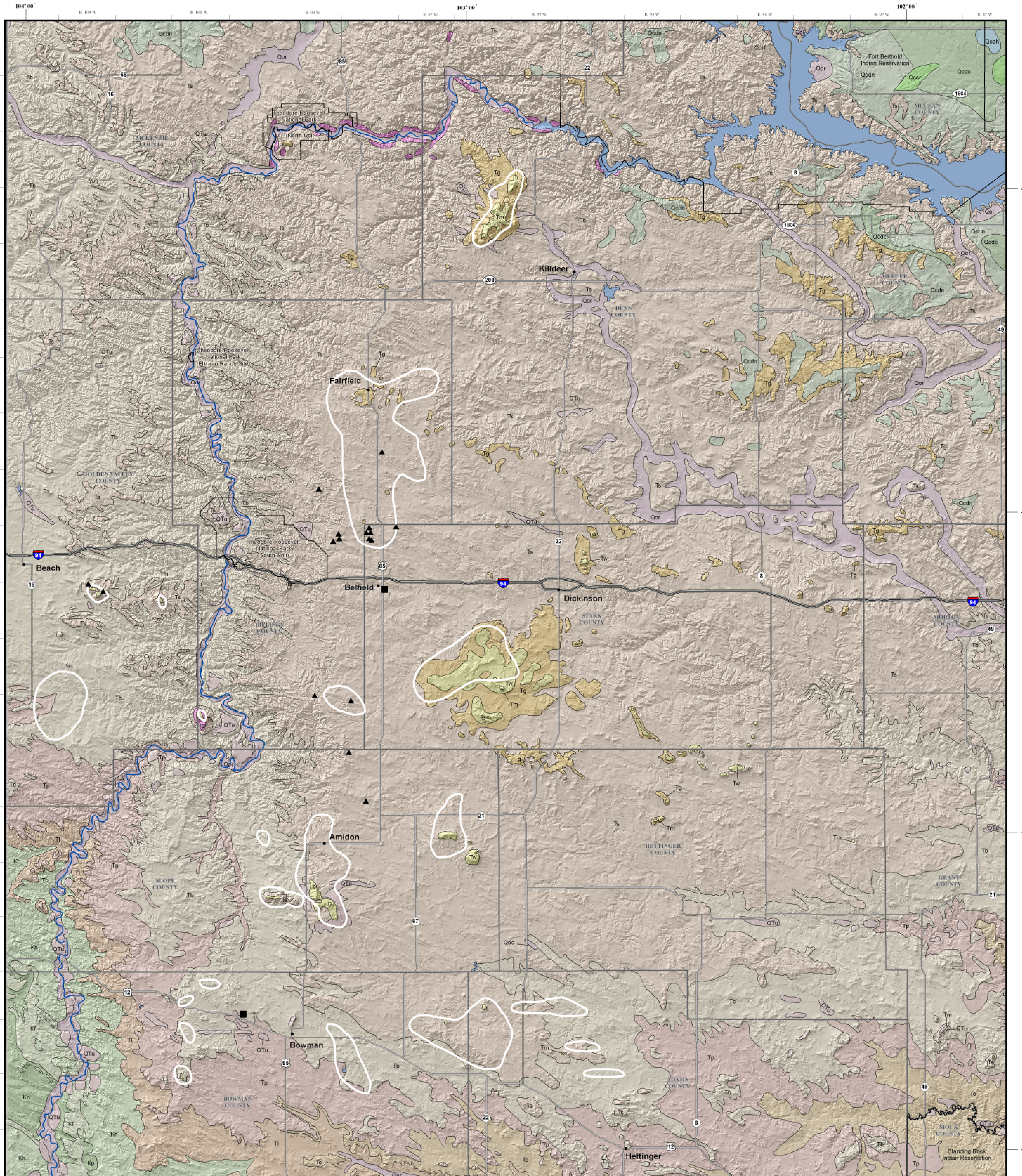
2007



Introduction

There are at least 21 areas in western North Dakota that contain uranium, primarily within lignites, sandstones, or carbonaceous mudstones. These deposits encompass an area of approximately 250,000 acres. Seven of these deposits cover more than 10,000 acres and one of these, a deposit north of Belfield, extends over an area of more than 83,000 acres. These deposits have been delineated primarily by plotting the locations of gamma logs that contain spikes (high gamma counts). The majority of these gamma logs come from exploratory drill holes generated by mineral companies exploring for uranium in the 1970s. Gamma logs from mineral companies exploring for coal in western North Dakota have also been useful in defining the extent of these deposits. Additional information was also obtained from uranium analyses published in US Geological Survey reports from the 1950s and 1960s.

Exploration and Mining in the 1950s and 1960s

The scientists exploring for uranium in southwestern North Dakota in the 1950s and 1960s came to several important conclusions early in their studies. In the mid-1950s, the volcanic-rich White River and Arikaree strata were identified as likely source rocks for the uranium found in carbonaceous rocks and sandstones in Hell Creek to Golden Valley strata (Late Cretaceous to Eocene) in southwestern North Dakota and northwestern South Dakota (fig. 1) (Hager, 1954; Denson et al., 1959; Denson and Gill, 1965). The White River and Arikaree rocks sit unconformably on progressively older rocks from north to south (Killdeer Mountains to Medicine Pole Hills) (fig. 2) across western North Dakota. The lack of concentration of uranium within one stratigraphic unit, along with the apparent fact that uranium was restricted to rocks that occurred within 200 feet of the White River unconformity, led scientists to conclude that White River and Arikaree strata were the source rocks (Denson et al., 1959; Moore et al., 1959). Although extensive drilling by mineral companies in the 1970s generated gamma logs that indicate zones of uranium are present more than 800 feet below the probable position of the White River unconformity, the White River and Arikaree source rock theory is still valid (Murphy, 2005; 2006a-c; 2007). The general appearance of White River and Arikaree strata (light colors, lack of organics, lack of iron, etc) suggests these rocks have been heavily oxidized and leached, further validating this theory (Murphy et al., 1993). Denson and others (1959) noted, by way of a written communication with Farrington Daniels, that the uranium content was relatively uniform throughout White River and Arikaree strata. Daniels' study area was not identified, but it may have been Nebraska or another state where there are extensive deposits of these rocks. In western North Dakota, the remnants of White River and Arikaree strata are, for the most part, only preserved on major buttes that are typically scattered 20 to 30 miles apart. It would be difficult to say anything meaningful about the homogeneity or heterogeneity of these rocks in relation to uranium given the lack of outcrop control. Although most of the uranium deposits depicted on this map are either beneath or immediately adjacent to White River strata, others, such as the deposits southeast of Golva and north of Belfield, are not. These latter deposits may be the result of increased uranium concentrations in White River strata long since leached and eroded, a reflection of the topography on the White River unconformity (ie., topographic lows), areas where uranium-bearing sediments derived from the erosion of White River strata were concentrated and later leached into the underlying rocks, or a combination of these three factors.

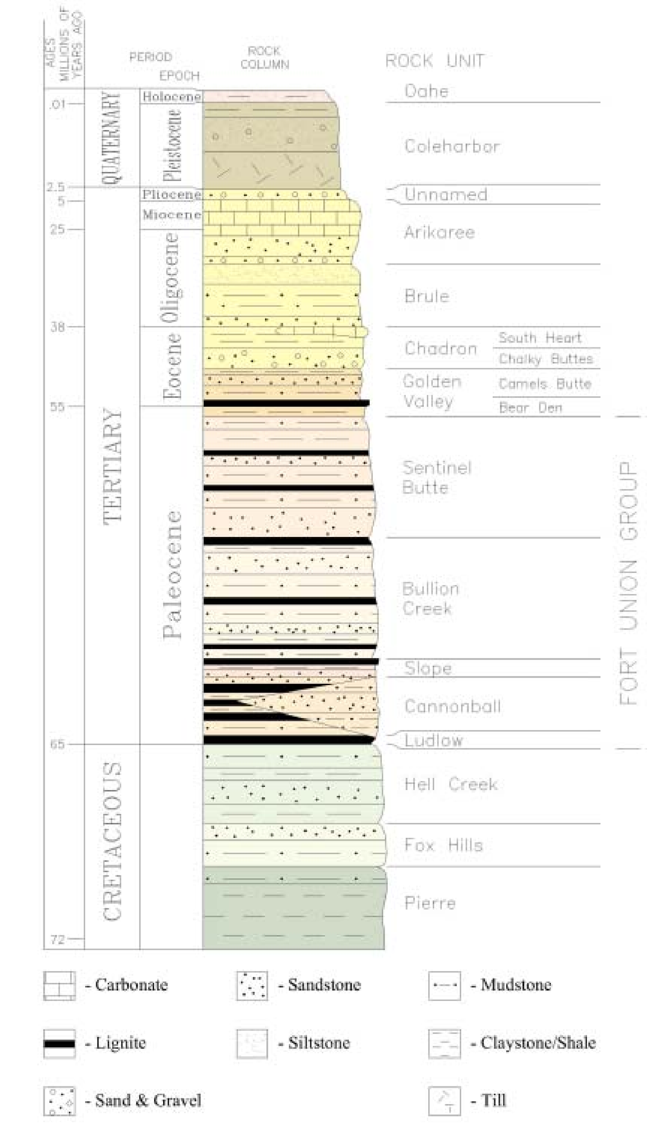


Figure 1. Generalized stratigraphic column for western North Dakota. This column is color coordinated with the map and figure 2.

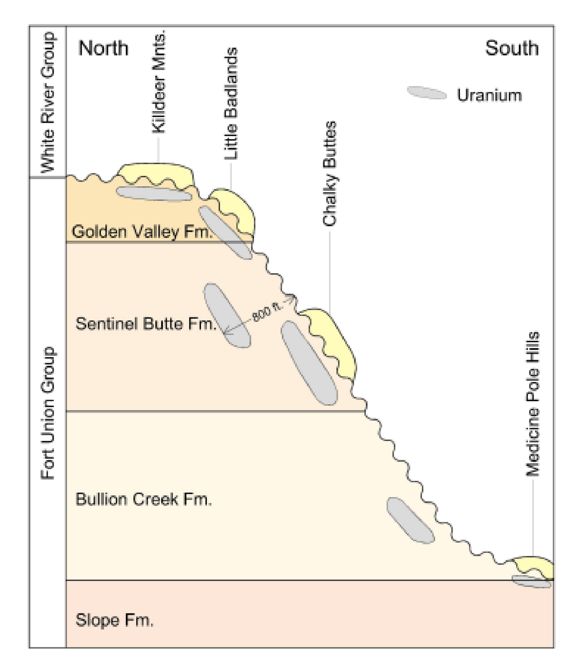


Figure 2. The stratigraphic position of the White River unconformity and uranium deposits in western North Dakota. Modified from Murphy et al., 1993.

Discovery of uraniferous lignite deposits in western North Dakota by federal scientists led several energy companies to explore for uranium in western North Dakota during the 1950s. In addition, some limited mining also took place during this decade. The mined ore was sent to processing centers where they were attempting to devise an economic method of removing the uranium from the coal. Mining on a larger scale occurred between 1962 and 1968 when somewhere between 9 and 15 mines in western North Dakota produced 85,138 tons of ore which yielded 592,288 pounds of U_3O_8 "yellow cake" (Karsmizki, 1990). Unfortunately, the mining records are very incomplete. Many of the mines burned the uraniferous lignite in place, a process that reportedly took 30 to 60 days to complete. After 1964, uraniferous lignite could also be shipped to either Belfield or Griffin for processing. Once the uraniferous lignite had been reduced to ash, either at the mine site or at the Belfield or Griffin sites, it was shipped to South Dakota, Colorado, or Utah for further processing.

Exploration in the 1970s

In 1976, mineral companies renewed uranium exploration activities in western North Dakota when uranium prices reached $40 per pound. More than 1,300 exploration holes were drilled between 1976 and1978. Most of these holes were drilled in Slope, Bowman, Adams, Billings, and Stark counties. An accident at the Three Mile Island nuclear power plant in Pennsylvania in March of 1979, coinciding with the release of the movie China Syndrome (a movie critical of nuclear power plant safety) turned many people in this country against nuclear power. As a result, orders for new power plants ceased and most uranium exploration in the region came to a halt as many energy companies disbanded their mineral divisions.

In the 1950s and 60s, scientists suggested several depositional models for predicting the occurrence of uranium in western North Dakota. Amongst those suggested was that uranium is always found within 200 feet of the White River unconformity, that the first lignite beneath the White River unconformity contains the most uranium, that uranium content within uraniferous lignites decreases from top to bottom within the bed, and uranium is generally found concentrated in lignites that are overlain by sandstone (Denson et al., 1959; Moore et al., 1959). As previously noted, we now know zones of uranium are present much deeper below the estimated position of the White River unconformity than was initially reported (fig. 3). In areas such as Bullion Butte, Square Butte, and Sentinel Butte, the first lignite beneath the White River unconformity does contain the most uranium. In other areas, such as near Fairfield, the seventh lignite from the surface is the most uraniferous, occurring some 200 feet beneath the stratigraphically highest lignite. Although the uraniferous lignite in this area is immediately overlain by a sandstone, this example still serves to demonstrate how unpredictable the occurrence of uranium can be in some areas of western North Dakota.

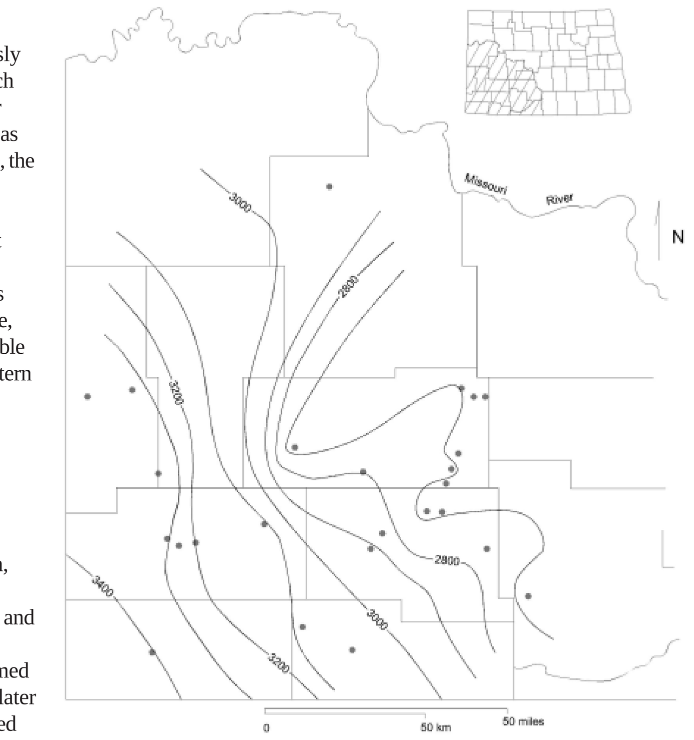


Figure 3. Contour map of the White River unconformity in western North Dakota. Modified from Murphy et al., 1993.

Potential Health Problems Associated with Uranium

The health effects to miners in western North Dakota due to exposure to increased levels of radiation, radioactive smoke and dust, and radon has not been studied. Increased levels of radioactivity are present in and around the old processing sites at Griffin and Belfield (DOE, 1989). None of the uranium mines were reclaimed at the time that they were abandoned in the 1960s and later studies indicated that those sites also contained increased levels of radioactivity. However, over the last twenty years or so, the North Dakota Public Service Commission has reclaimed several of these mine sites under their Abandoned Mine Lands Program. In addition to increased radioactivity, these abandoned mines may also pose a threat to livestock due to molybdenosis (molybdenum poisoning). It was documented in the 1950s that increased concentrations of uranium were generally accompanied by increases in molybdenum and other trace metals (Zeller and Schopf, 1959). There have been at least three documented cases of molybdenosis in livestock that had been foraging around abandoned uranium mines or processing sites in the 1960s and 1970s. Any future uranium mining in North Dakota would likely involve in-situ leaching of sandstone. Mining and processing of uraniferous lignites in an environmentally sound manner would prove difficult.

The mobility of uranium and associated trace metals in groundwater within these settings is another area for concern. Between 1975 and 1992, three separate studies analyzed about 3,600 water samples from southwestern North Dakota for uranium. Three to14% of the samples collected in these studies exceeded uranium concentrations of 100 micrograms per liter (Roberts, 1992). The U.S. Environmental Protection Agency's maximum contaminant level for uranium is 30.

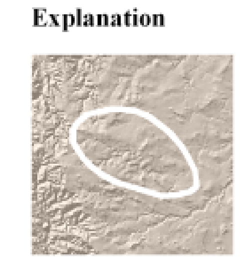
Current Market for Uranium

In January, 2007, the spot market price for U_3O_8 was $72 per pound as compared to $21 in January of 2005 and $9.60 in January, 2002. This dramatic price increase is a result of the shortfall of uranium between what the 435 nuclear reactors operating in the world need and what is currently being produced. The shortfall, which equates to 70 million pounds of uranium per year, has been made up by depleting stockpiles that were built up during the last boom cycle and by conversion of nuclear weapons, both of which are diminishing (Mathews, 2006). Projections show this shortfall steadily increasing in the future. As a result, for the first time in 28 years, there is renewed interest in North Dakota's uranium deposits.

References

Department of Energy, 1989, Environmental assessment of remedial action at the inactive uraniferous lignite processing sites at Belfield and Bowman, North Dakota: DOE/EA – 0346, DE91 005808, 82 p.
Denson, N.M., Bachman, G.O., and Zeller, H.D., 1959, Uranium-bearing lignite in northwestern South Dakota and adjacent states: in Uranium in coal in the western United States, U.S. Geological Survey Bulletin 1055, pp. 11-57.
Denson, N.M., and Gill, J.R., 1965, Uranium-bearing lignite and carbonaceous shale in the southwestern part of the Williston Basin — a regional study: United States Geological Survey Professional Paper 463, 75 p.
Hager, Dorsey, 1954, Uranium – the volcanic ash theory: Uranium, v. 1, n. 1, pp. 12-13.
Karsmizki, K.W., 1990, U3O8, uranium industry context statement, prepared for UNDAR-West: Western History Research, Bozeman, Montana, 79 p.
Knell, Mark, 2004, Uraniferous mine reclamation, ND Public Service Commission website, AML Division, one page.
Mathews, Vince, 2006, From the division director: Colorado Geological Survey Rocktalk, v. 9, n. 2, p 2.
Moore, G.W., Melin, R.E., and Kepferle, R.C., 1959, Uranium-bearing lignite in southwestern North Dakota: in Uranium in coal in the western United States, U.S. Geological Survey Bulletin 1055, pp. 147-166.
Murphy, E.C., Hoganson, J.W., and Forsman, N.F., 1993, The Chadron, Brule, and Arikaree Formations in North Dakota; the buttes of southwestern North Dakota: North Dakota Geological Survey Report of Investigation No. 96, 144 p.
Murphy, E.C., 2005, The uranium resources of the Bowman 100K sheet: North Dakota Geological Survey 100k Bwmn - u, 1:100,000 scale.
Murphy, E.C., 2006a, The uranium resources of the Belfield 100K sheet: North Dakota Geological Survey 100k Blfd - u, 1:100,000 scale.
Murphy, E.C., 2006b, The uranium resources of the Mott 100K sheet: North Dakota Geological Survey 100k Mott - u, 1:100,000 scale.
Murphy, E.C., 2006c, The uranium resources of the Dickinson 100K sheet: North Dakota Geological Survey 100k Dksn - u, 1:100,000 scale.
Murphy, E.C., 2007, The uranium resources of the Grassy Butte 100K sheet: North Dakota Geological Survey 100k GrBt - u, 1:100,000 scale.
Roberts, K.D., 1992, A survey of naturally occurring uranium in groundwater in southwestern North Dakota: North Dakota State Department of Health, Division of Water Quality Report, 12 p.
Zeller, H.D. and Schopf, J.M., 1959, Core drilling for uranium-bearing lignite in Harding and Perkins counties, South Dakota, and Bowman County, North Dakota: in Uranium in coal in the western United States, U.S. Geological Survey Bulletin 1055, pp. 59-146.

Explanation



Uranium Deposits

These deposits were defined using gamma counts interpreted from uranium and coal exploration gamma logs. These zones occur one to 500 feet beneath the surface. Due to poor well control through much of the area, these deposits might be more expansive than indicated on this map.

▲ **Uranium Mine Operated in the 1950s or 1960s.**

■ **Uranium Processing Site Operated in the 1960s.**

Explanation of Surface Geologic Units

OAHE FORMATION (HOLOCENE AND PLEISTOCENE)

- **Qor** River Sediment (Holocene)
- **Qod** Windblown Sand (Holocene)
- **Qol** Windblown Silt (Holocene and Wisconsinan)
- **QTou** Sand (Holocene To Pliocene)

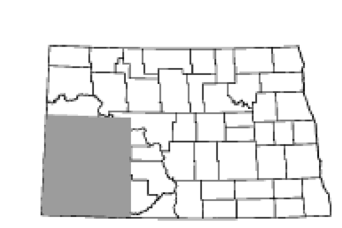
COLEHARBOR FORMATION (HOLOCENE AND PRE-WISCONSINAN)

- **Qcoh** Ice-Walled-Lake Sediment
- **Qcrf** Uncollapsed River Sediment
- **Qccr** Collapsed Glacial Sediment - Rolling
- **Qcdc** Collapsed/Draped Transition Sediments
- **Qcdn** Glacial Sediment Draped Over Pre-Existing Non-Glacial Topography

- **QTu** QUATERNARY AND UPPER TERTIARY SEDIMENT, UNDIVIDED
- **Tm** UPPER AND MIDDLE TERTIARY ROCK, UNDIVIDED
- **Tw** WHITE RIVER GROUP (OLIGOCENE)
- **Tg** GOLDEN VALLEY FORMATION (EOCENE AND PALEOCENE)
- **Ts** SENTINEL BUTTE FORMATION (PALEOCENE)
- **Tb** BULLION CREEK FORMATION (PALEOCENE)
- **Tp** SLOPE FORMATION (PALEOCENE)
- **Tc** CANNONBALL FORMATION (PALEOCENE)
- **Tl** LUDLOW FORMATION (PALEOCENE)
- **Kh** HELL CREEK FORMATION (UPPER CRETACEOUS)
- **Kf** FOX HILLS FORMATION (UPPER CRETACEOUS)
- **Kp** PIERRE FORMATION (UPPER CRETACEOUS)

Geologic and Misc Surface Symbols

- Contact Between Surface Geologic Units
- **Ls** Landslides
- Water
- County Boundaries
- Highways
- Tribal and National Park Service Boundaries



Southwestern North Dakota

Scale 1:360,000

0 3 6 9 12

Miles

Mercator Projection

1927 North American Datum

USGS NED Shaded Relief - Vertical Exaggeration 9x

N W E S

The geologic map that was used as the base for this map was modified from: Clayton, Lee, Moran, S.R., Bluemle, J.P., and Carlson, C.G., 1980, Geologic Map of North Dakota: U.S. Geological Survey, 1:500,000 scale.