

URANIUM IN NORTH DAKOTA



Edward C. Murphy
GEOLOGICAL INVESTIGATIONS NO. 184
NORTH DAKOTA GEOLOGICAL SURVEY
2015

Authors Note: Unfortunately, little or no information was recorded at the state level regarding uranium exploration and mining due to national security and the lack of state oversight. In 1990, Ken Karsmizki compiled a 79 page report for UNDAR-West entitled *U₃O₈ Uranium Industry Context Statement*, a good source of information for early uranium mining in North Dakota. For this presentation, I supplemented Karsmizki's report and information from the Abandoned Mine Lands Division of the North Dakota Public Service Commission with information garnered from discussions with geologists involved in the uranium mining in North Dakota in the 1960s as well as those involved in uranium exploration in the state during the 1970s.

Variations on this PowerPoint were presented to 1,100 people in Belfield, Bismarck, Bowman, Dickinson, and Mandan between 2008 - 2012.

Uranium in North Dakota, North Dakota Geological Society, Bismarck, February 22, 2008.

The Proposed ISL Uranium Rules for North Dakota, Public Informational Meeting, Belfield, March 10, 2008.

Uranium in North Dakota, Golden Kiwanis, Bismarck, April 30, 2008.

Uranium in Western North Dakota, Dickinson Rotary Club, July 9, 2008.

Uranium in Western North Dakota, EmPower Group, Bismarck, December 12, 2008.

Uranium in Western North Dakota, Bismarck Rotary Club, January 12, 2009.

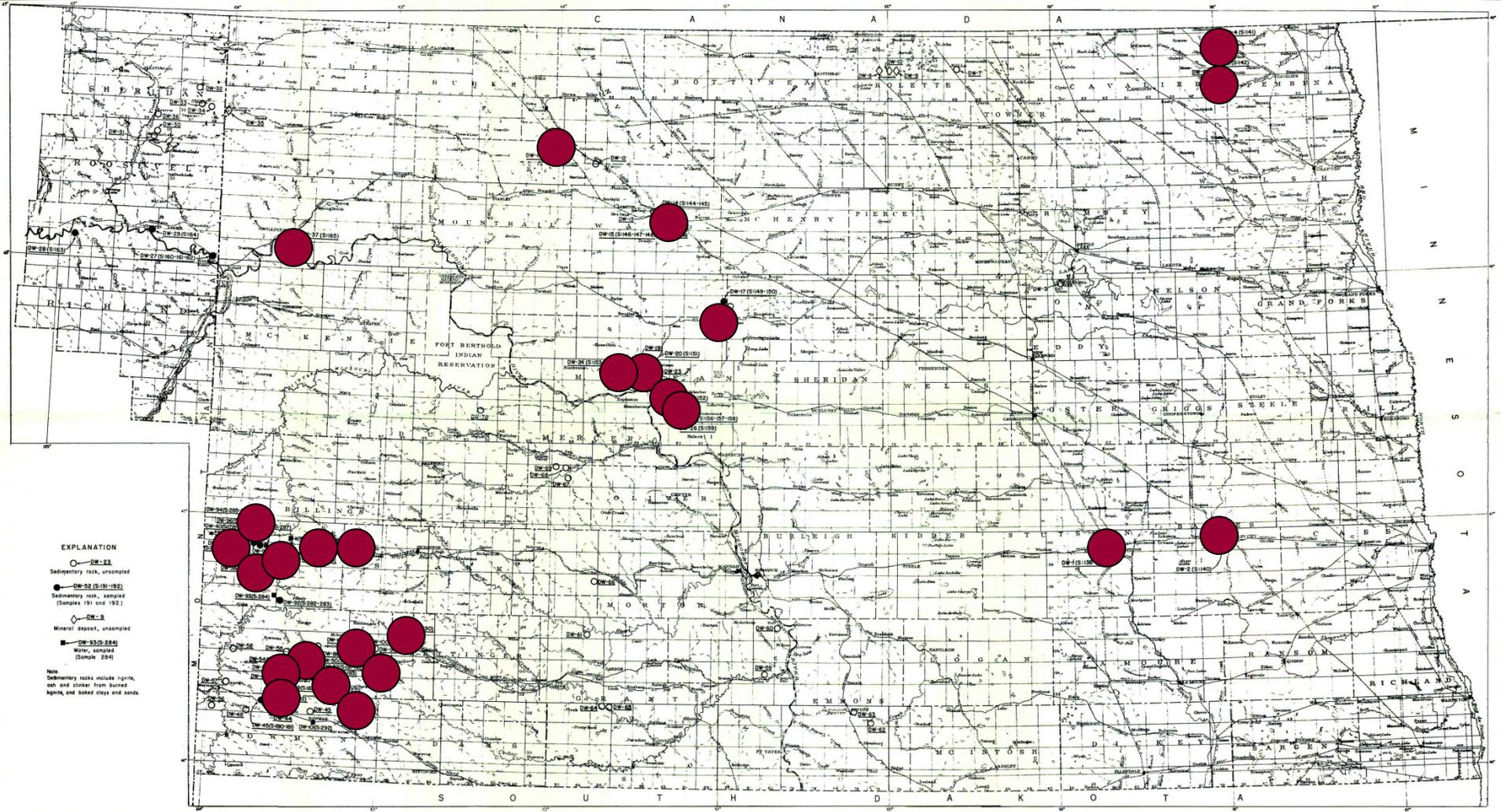
Uranium development in Western North Dakota, North Dakota Chapter of the Wildlife Society, Mandan, February 11, 2009.

Uranium in Southwestern North Dakota, North Dakota Earth Science Teachers Conference, Bismarck State College, March 6, 2009.

Uranium in North Dakota, Bowman County Economic Development Association, December 14, 2010.

Mineral Potential of Southwestern North Dakota, Bowman, January 23, 2012.

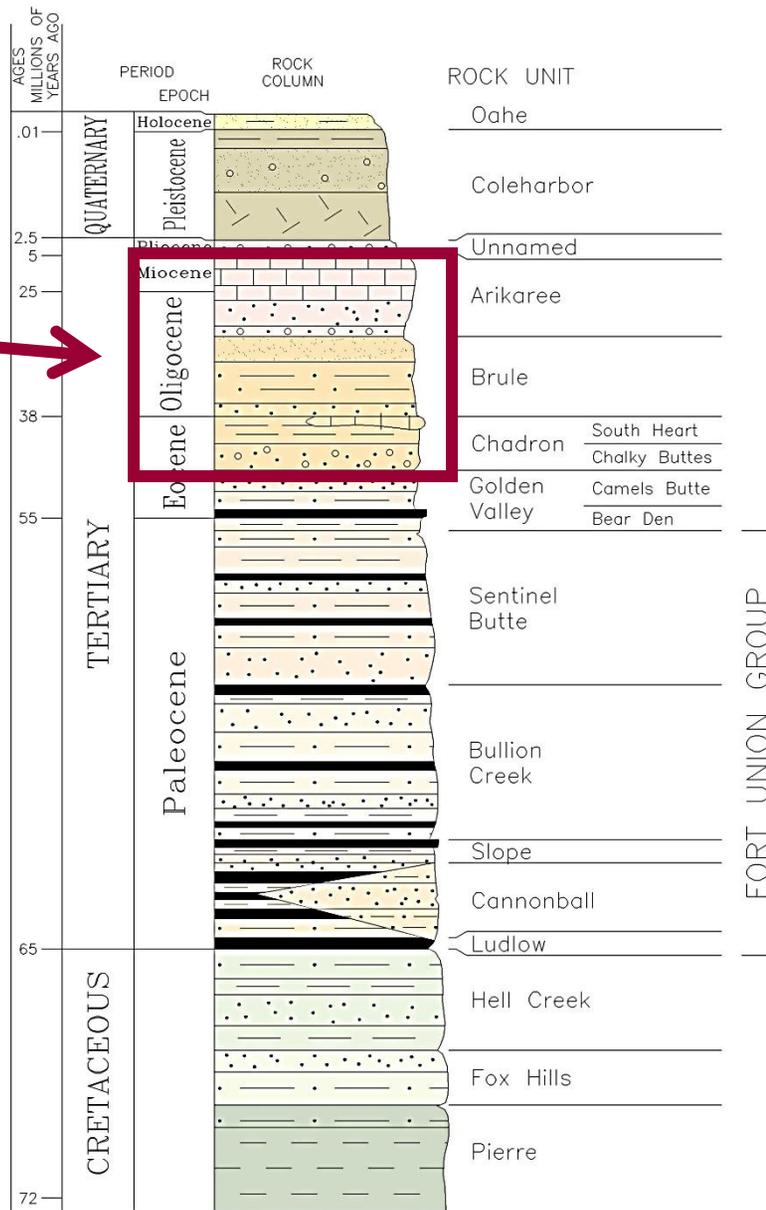
Energy Resources of the Williston Basin, Soil Conservation Districts Annual mtg, Bismarck, November 19, 2012.



LOCALITIES IN NORTH DAKOTA AND NORTHEASTERN MONTANA EXAMINED FOR RADIOACTIVE ROCKS

In 1948 and 1949, Wyant and Beroni (1950) collected 82 samples from 86 localities (red dots) – the first reported widespread uranium exploration to take place in North Dakota.

Source rocks for uranium deposits



Arikaree Fm.

White River Group

Sentinel Butte Fm.

- [Pattern] - Carbonate
- [Pattern] - Sandstone
- [Pattern] - Mudstone
- [Pattern] - Lignite
- [Pattern] - Siltstone
- [Pattern] - Claystone/Shale
- [Pattern] - Sand & Gravel
- [Pattern] - Till



The Arikaree and White River rocks are typically only found preserved on the major buttes in western North Dakota. Chadron rocks overlie this massive sandstone (Golden Valley Formation) at Bullion Butte in Billings and Golden Valley counties.



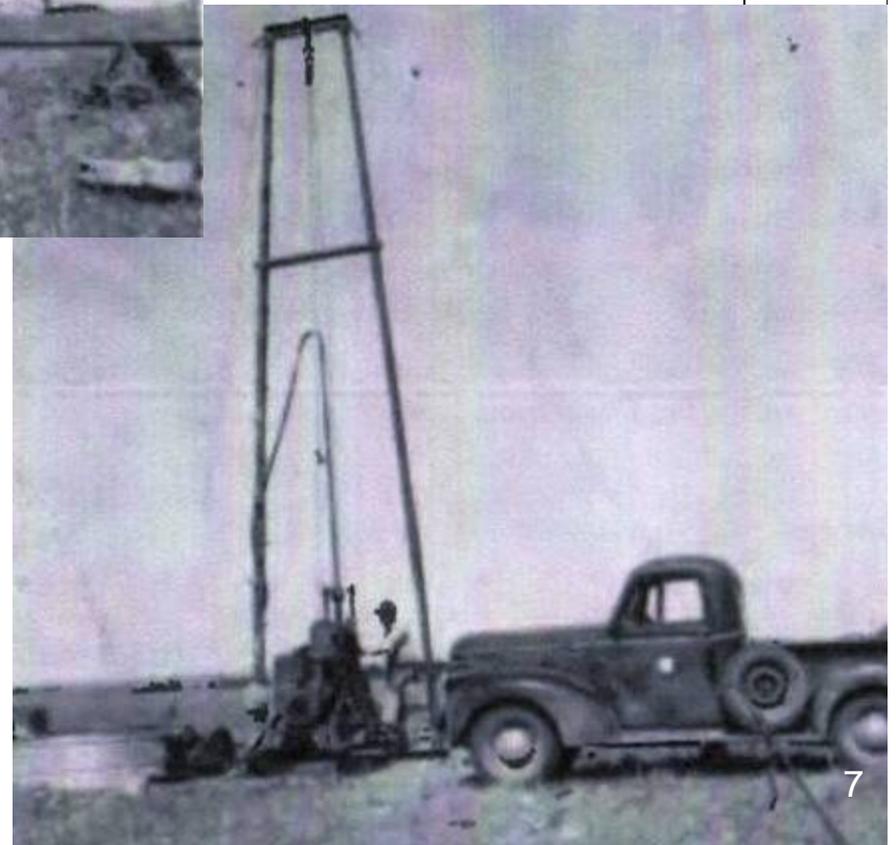
Chadron claystones and conglomerates overlie the 75-foot-thick sandstone caprock (Golden Valley Formation) on Square Butte, Golden Valley County.



Fifty feet of Chadron claystone overlies the sandstone caprock (Golden Valley Fm) on Sentinel Butte in Golden Valley County.



Uranium exploration in North Dakota, South Dakota, Montana, or Wyoming in the 1940s and 1950s.



T6712
NO. 238

~~CONFIDENTIAL~~
~~SECURITY INFORMATION~~

Geology - Mineralogy

This document consists of
104 pages, plus 3 figures.
No. 43 of 58 copies, Series
A.

Early uranium reports were
sometimes restricted in distribution
due to security concerns.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

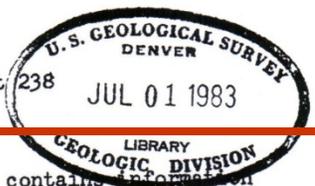
RESULTS OF CORE DRILLING OF URANIUM-BEARING
LIGNITE DEPOSITS IN HARDING AND PERKINS COUNTIES,
SOUTH DAKOTA, AND BOWMAN COUNTY, NORTH DAKOTA *

By
Howard D. Zeller

*Should include a statement
to the effect that this area
was drilled in 1951 by the U.S.,
G.S., and that the results
are in Chapter C.*

October 1952

Trace Elements Investigations Report 238

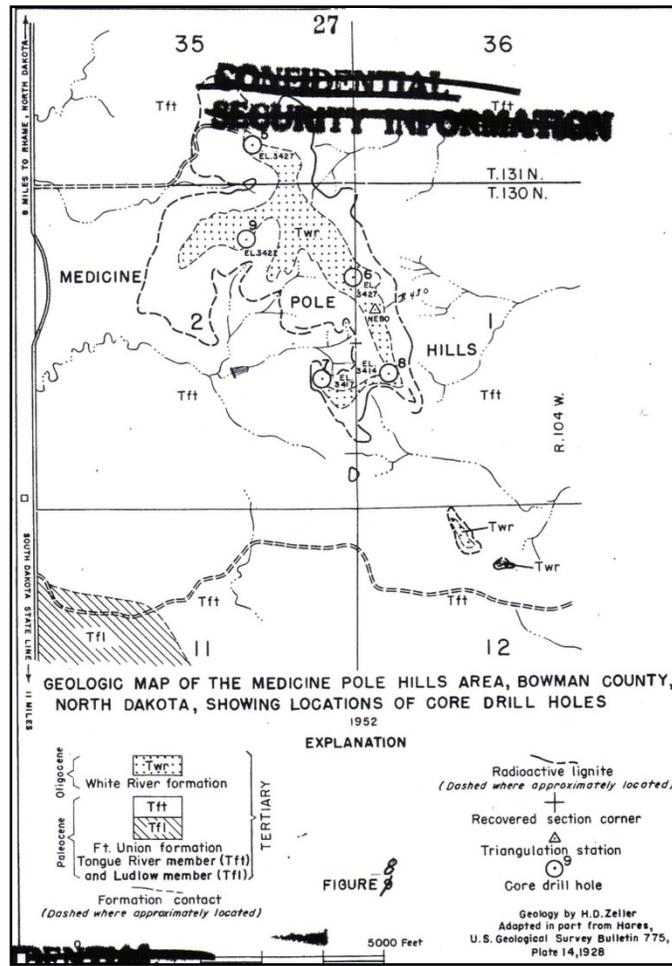


This preliminary report is distributed without editorial and technical review for conformity with official standards and nomenclature. It is not for public inspection or quotation.

This material contains information affecting the national defense of the United States within the meaning of the espionage laws, Title 18, U.S.C., Secs. 793 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by law.

* This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission

~~CONFIDENTIAL~~
~~SECURITY INFORMATION~~





An old uranium test pit east of the Kinley Plateau in Billings County. A number of test pits were excavated in North Dakota during the 1950s. The uraniumiferous lignite was sent to processing sites in New Mexico and Colorado to determine the best means of removing the uranium from the coal.



An old uranium test pit in north-central Billings County.

URANIUM MINES IN NORTH DAKOTA

Mining took place in North Dakota between 1962 – 1967.

Mine records were poor to nonexistent.

No state agency had jurisdiction over the mines at the time – the ND Geological Survey subsurface minerals program did not come into existence until 1968.

ND had somewhere between 9 – 14 uranium mines.

Some of these sites may have been large test pits.

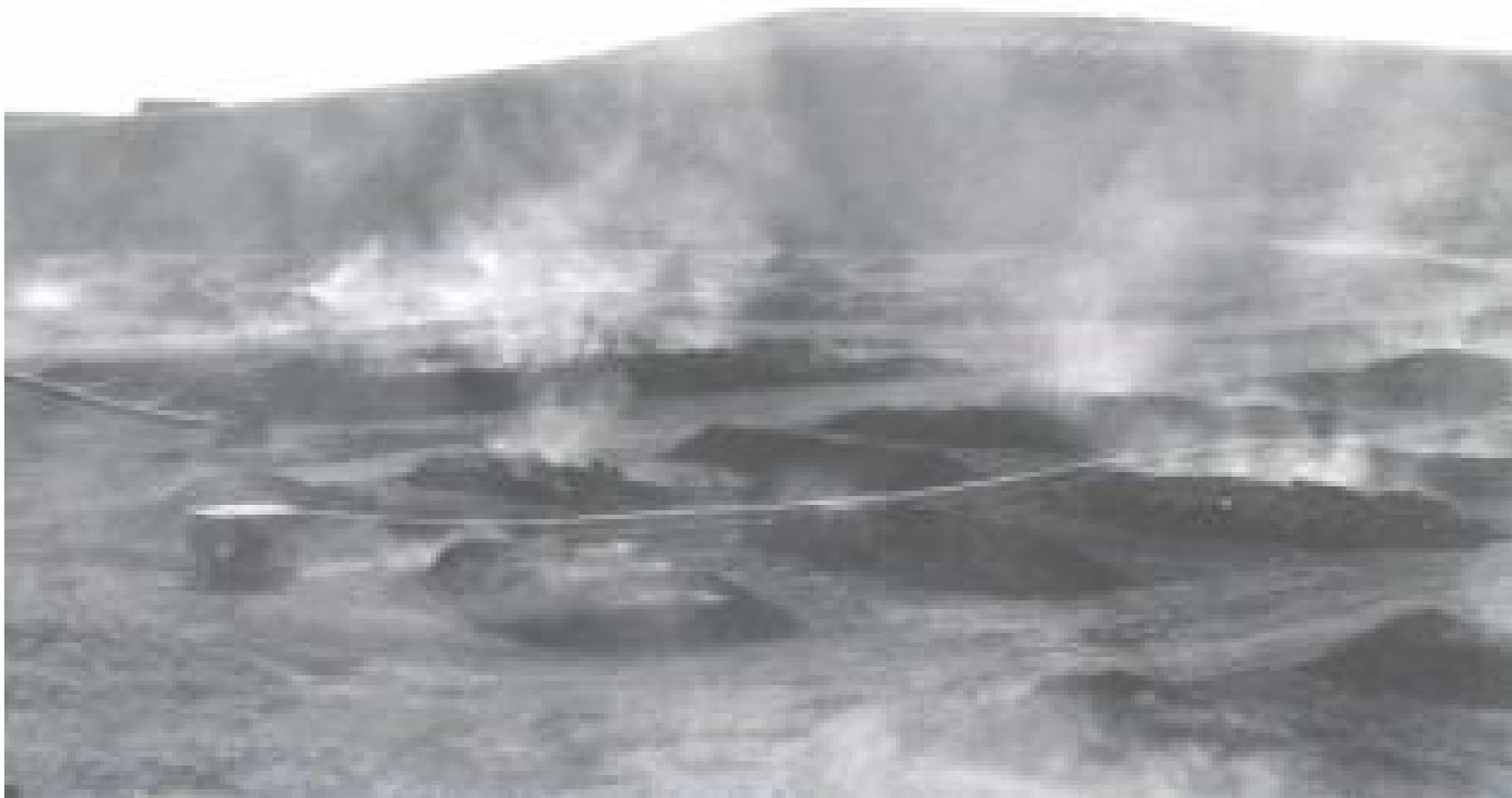
Mining was centered in the Belfield area and included:

Billings County

Stark County

Slope County

Golden Valley County



Uraniferous lignite was burned in the mine pit or in a rotary kiln in Belfield. The uraniferous lignite was placed in piles, covered with old tires, doused in diesel fuel, ignited, and left to smolder for a couple of months. This is believed to be the Fritz Mine and is the only photograph of a burn that I have been able to locate.

MINERAL COMPANIES ACTIVE IN NORTH DAKOTA: 1950s and 60s

- **Union Carbide Corporation**
- **Kerr-McGee**
- **Kermac Nuclear Fuels Corporation**
- **Susquehanna-Western Incorporated**
- **Geo Resources Exploration Incorporated**
- **Manidon Mining Company**
- **Uranco Mining and Exploration Company**
- **Minerals Mining Company**
- **Westinghouse**
- **Ohio Oil Company**
- **Landis-Gress-McCann-Getting Uranium Association**

URANIUM PROCESSING PLANTS

- Rifle, Colorado
- Ambrosia Lake, New Mexico (Kermac Nuclear Fuels Corp.)
- Edgemont, South Dakota (Mines Development Inc.)
- Riverton, Wyoming (only a small amount believed to be sent to this plant from North Dakota)

The uraniumiferous lignite was burned in the mine or in a kiln to reduce it to uraniumiferous ash -- a volume reduction of approximately 90%. The ash was then sent to one of these four plants where it was processed into uranium oxide (yellow cake).

ND ROTARY KILNS

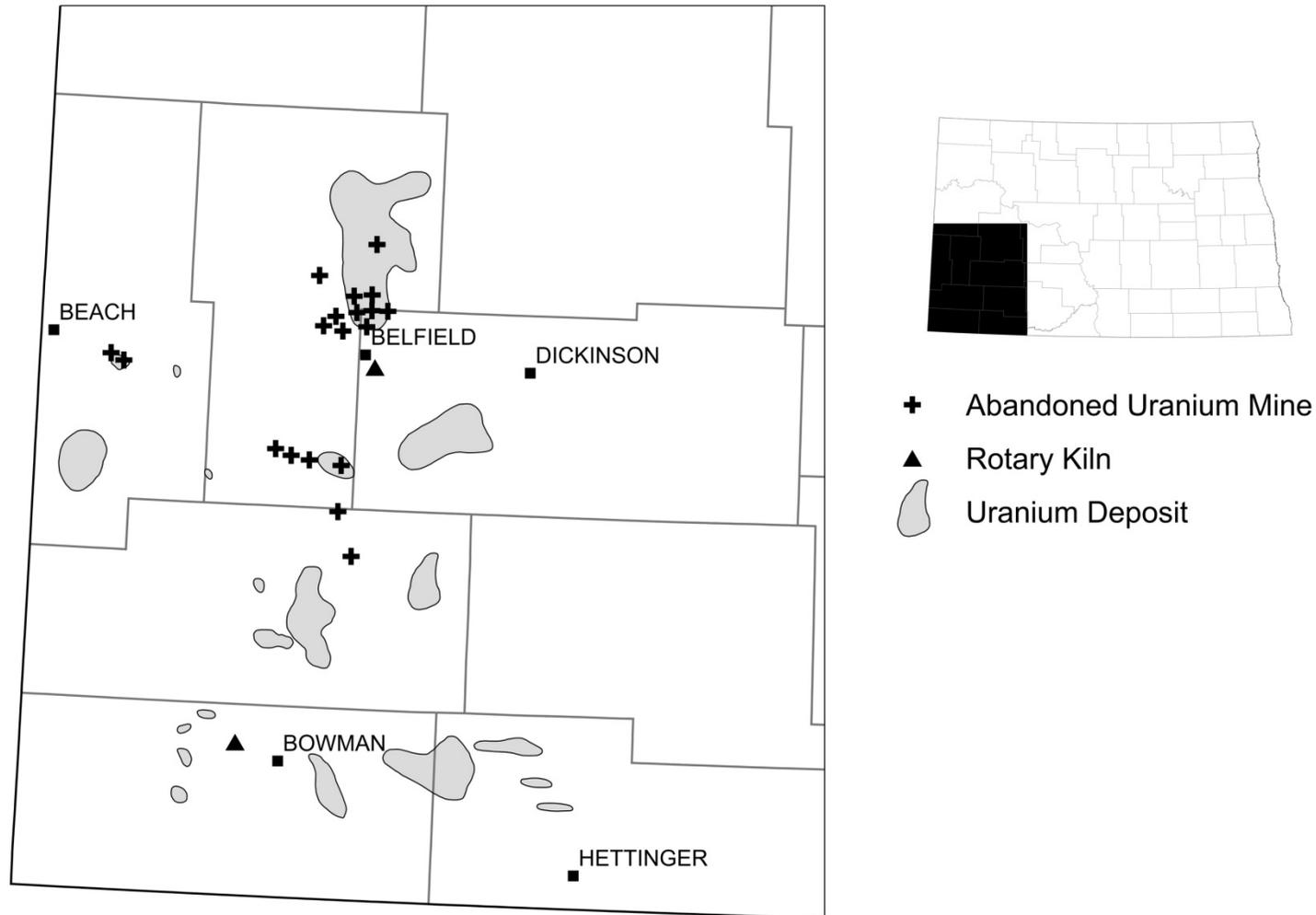
1964 -- 1967

- Union Carbide Corporation's plant at Belfield – one rotary kiln.
- Kermac Nuclear Fuels Corporation's plant at Griffin – three rotary kilns.

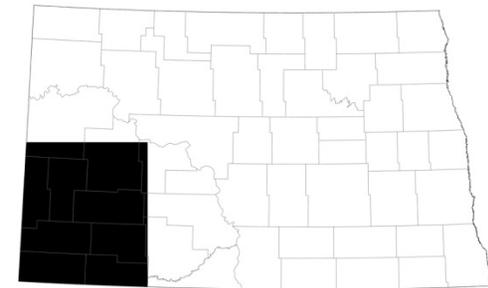
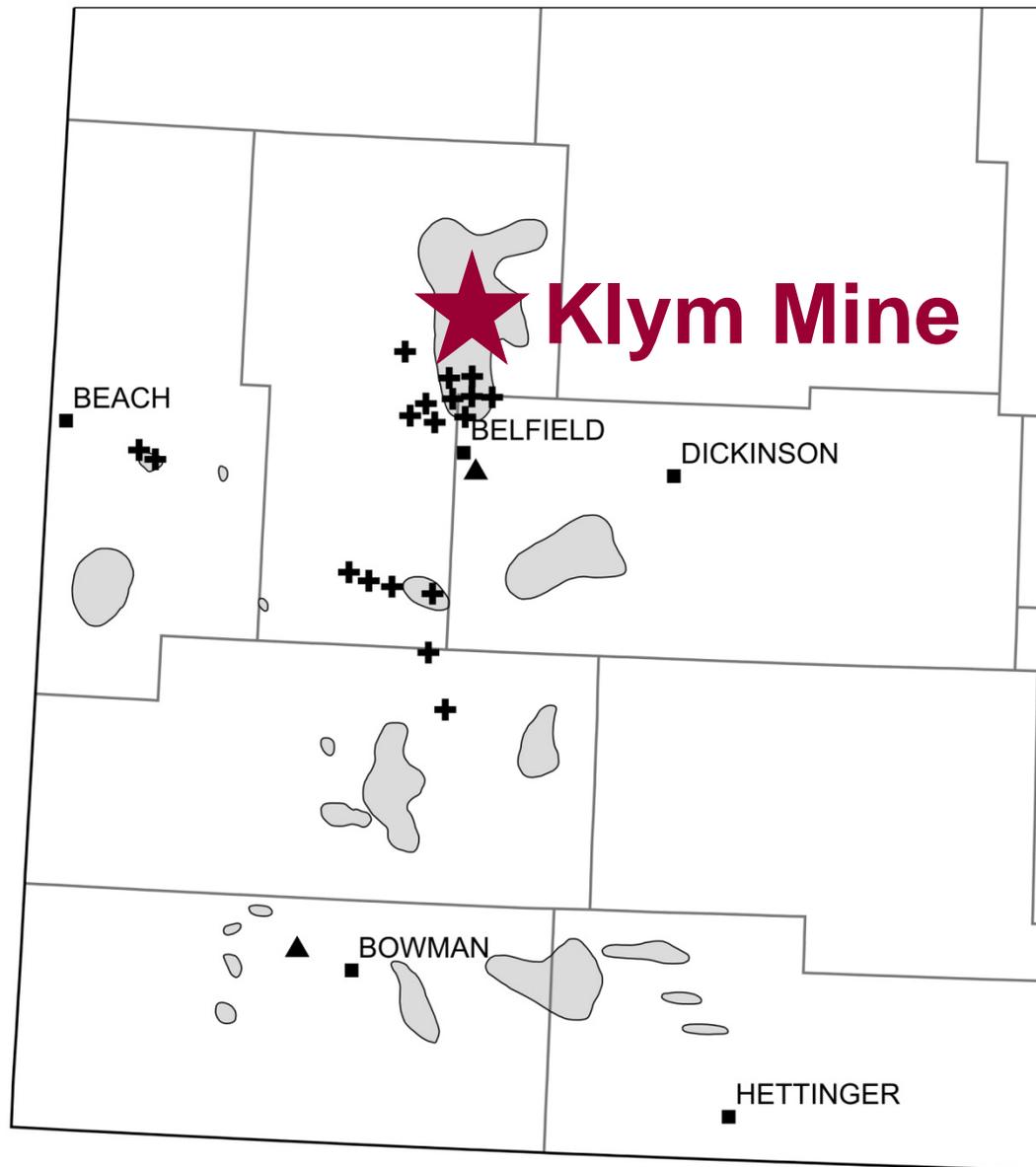


One of the Griffin rotary kilns was moved to Lehigh in Stark County to make clay aggregate. Today, this equipment still contains elevated levels of radioactivity.

URANIUM MINES IN NORTH DAKOTA



Nine to 14 uranium mines operated in North Dakota in the 1960s. A half dozen or more of the sites plotted here may have been test pits rather than mines.

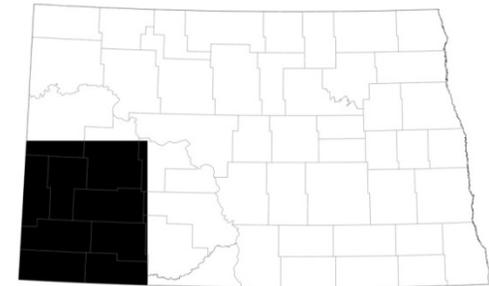
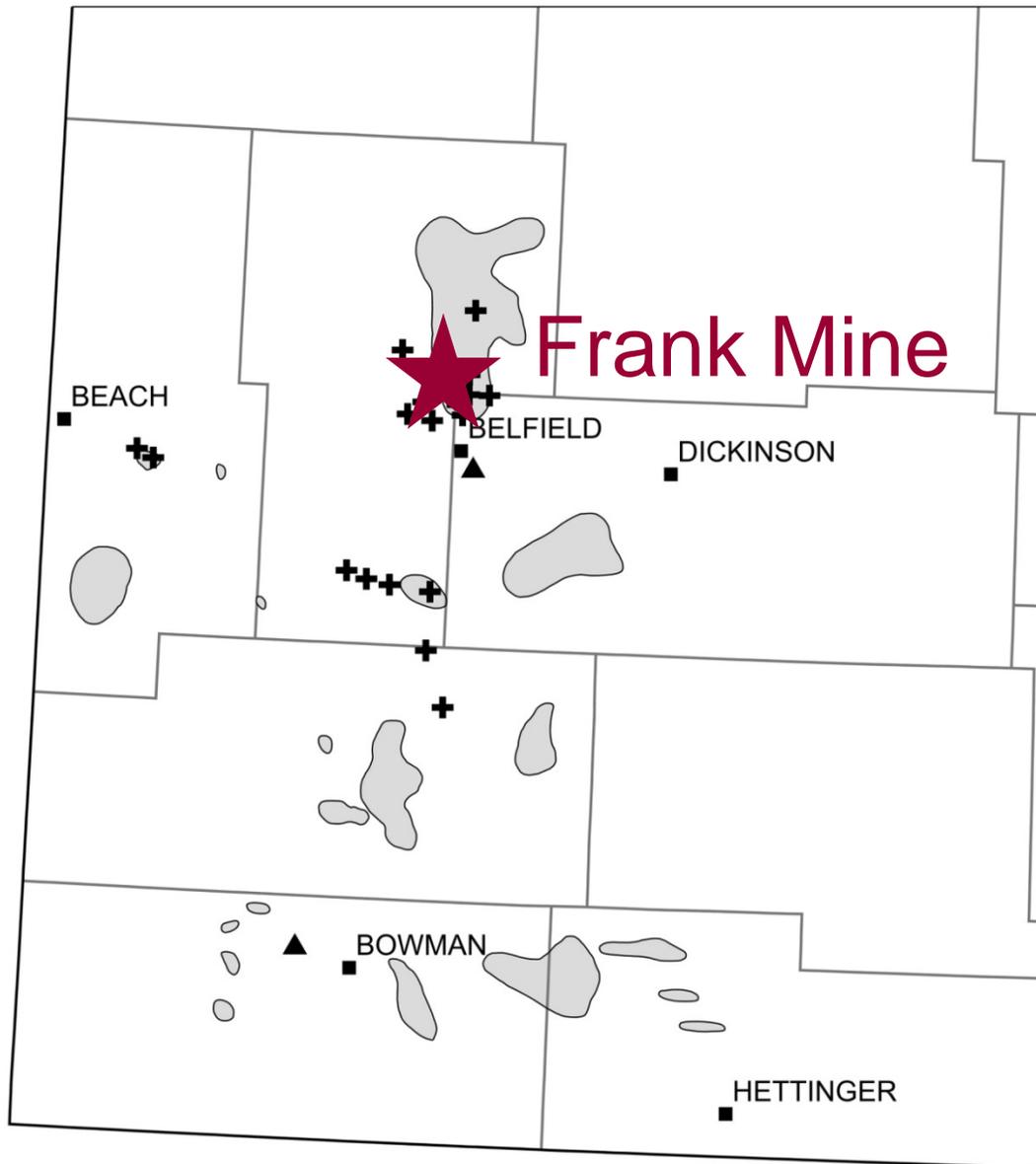


- + Abandoned Uranium Mine
- ▲ Rotary Kiln
- Uranium Deposit

Susquehanna-Western mined this site from 1967-1968. Mined about 25,000 tons of uraniferous lignite. Reportedly burned lignite on site and shipped the ash.



The Klym Mine in Billings County. The site was reclaimed in 1990.

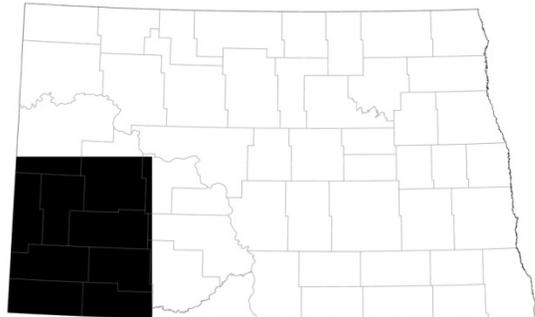
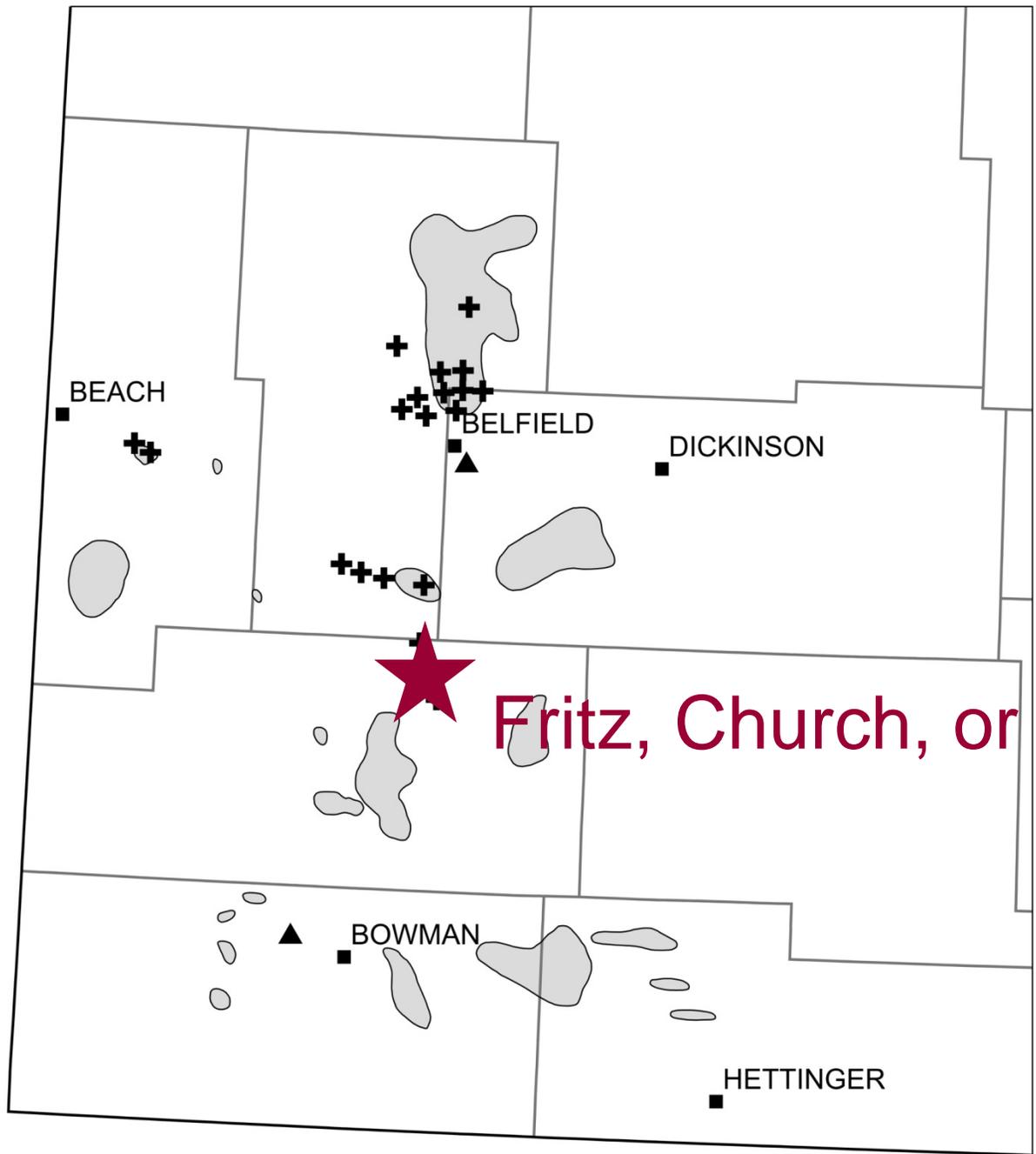


- + Abandoned Uranium Mine
- ▲ Rotary Kiln
- Uranium Deposit

Union Carbide produced about 50,000 tons of uraniferous lignite from the Frank Mine. This production figure may also include the Luptak, Palaniuk, Safratowich, Hecker, Rodowski, and Lindo mines.



In the distance, a portion of the reclaimed Frank Mine in Stark County. The mine was reclaimed in 1989. Photograph taken in 2007.



- + Abandoned Uranium Mine
- ▲ Rotary Kiln
- Uranium Deposit

Fritz, Church, or Hurick Mine



The Church or Fritz Mine in Slope County operated from 1962-1967 with test pits as early as 1956. The mine site covered approximately 155 acres. This is an oblique aerial photograph of the Fritz Mine taken by the ND Public Service Commission in 1990.

URANIUM ALLOCATIONS

1952-1962: The Atomic Energy Commission (AEC) grants U_3O_8 allocations on individual properties in the western U.S.

Late 1950s: The original allocations in North Dakota are granted on leased properties drilled by Ohio Oil.

Early 1960s: Marathon Oil proves properties in North Dakota.

1963: Marathon drops most of the leases (allotments remain with the mineral owners).

1963: Union Carbide and the other companies lease a number of the properties that contain allocations.

1967: The AEC allows companies to consolidate their allocations. Companies leave ND to locate closer to processing centers.

ATOMIC ENERGY COMMISSION CHANGES RULES IN THE MIDDLE OF THE GAME

In 1967, AEC allowed companies to obtain their allotted amount of uranium from any deposit. As a result, companies immediately stopped mining their more expensive holdings that were further from the uranium processing centers.

UNION CARBIDE

- **Frank Mine** (Luptak, Palaniuk, Safratowich, Hecker, Rodokowski, and Lindo)
 - *50,000 tons of lignite*

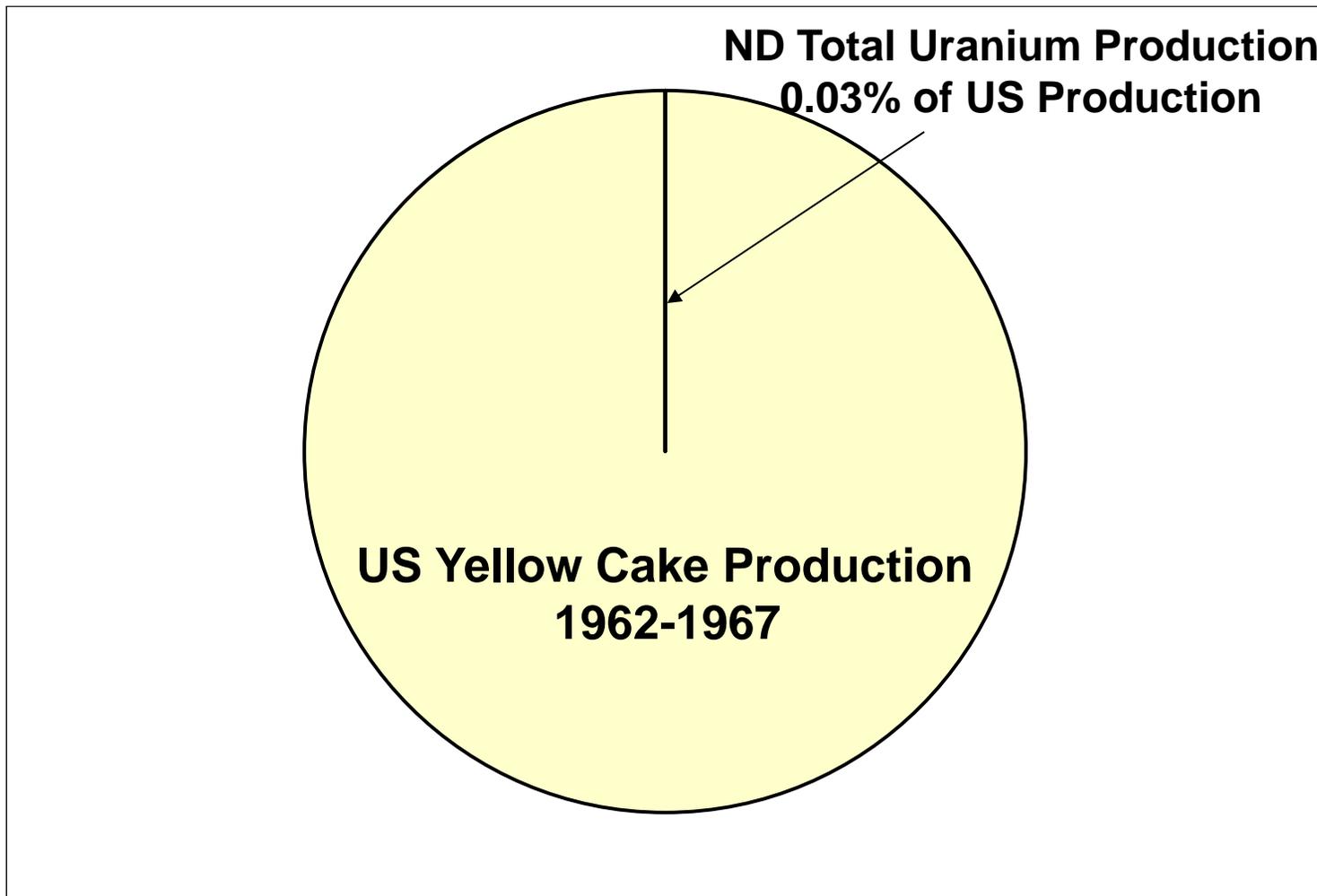
- **Others**

Talkington, Smith, Johnson, Munkries, and Howie (GeoResources) Mines.

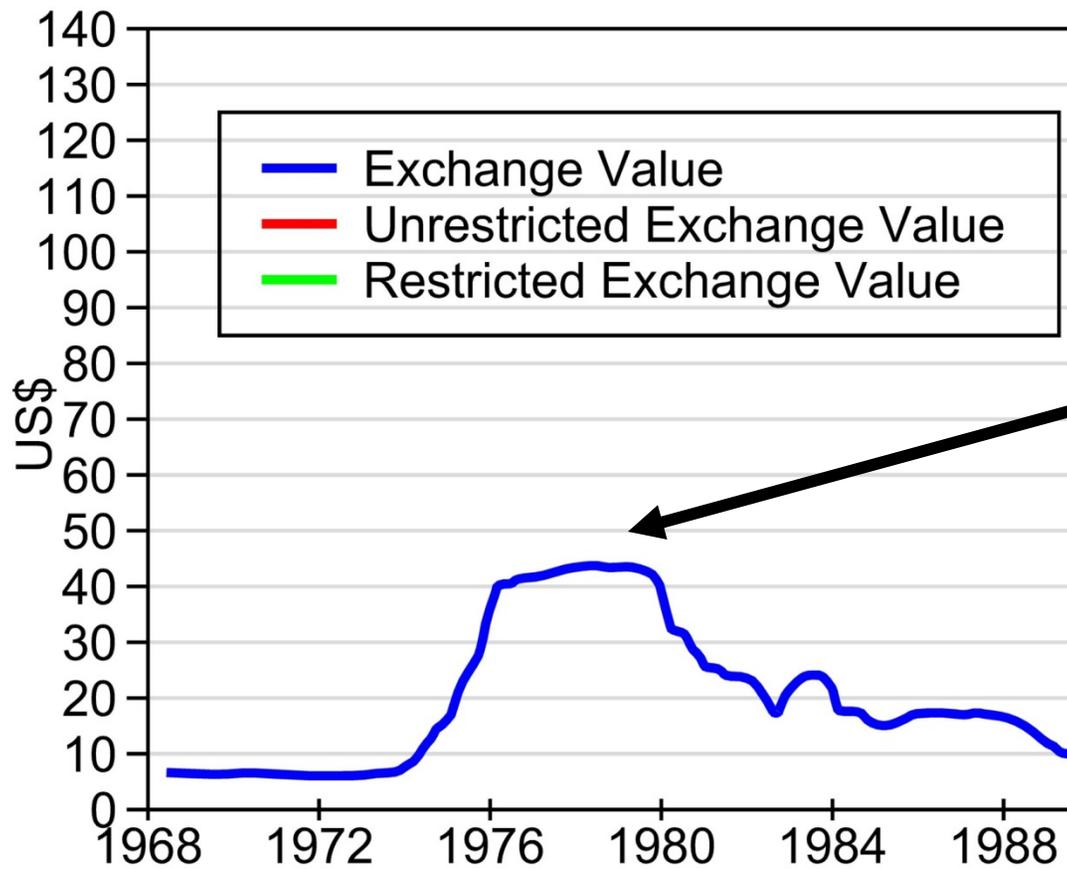
SUSQUEHANA WESTERN

- **Fritz Mine**
 - *40,000 tons of lignite*
- **Klym Mine**
 - *25,000 tons of lignite*

85,000 tons reported



592,288 (ND) vs 1,800,000,000 (US) pounds of yellow cake



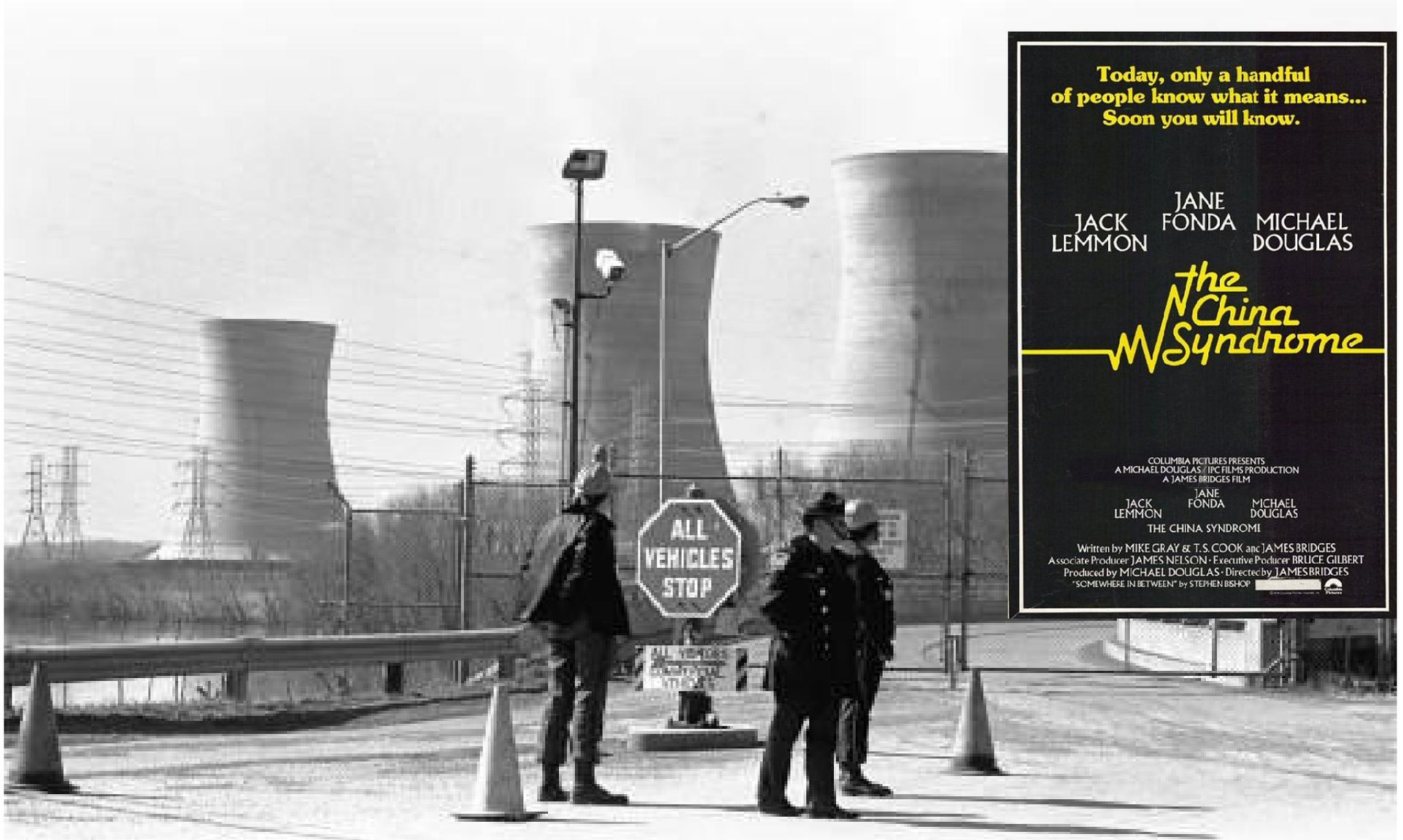
**Uranium exploration in
North Dakota
1976-1979**



Some of the uranium exploration that was conducted in the 1970s focused on the Chalky Buttes in Slope County.

MINERAL COMPANIES ACTIVE IN NORTH DAKOTA: 1976-1980

- Minatome Corporation
- North American Coal
- Power Resources Corporation
- Urex, Incorporated
- Framco
- BurWest (Burlington Northern Minerals)
- H&H Services
- Uranerz USA, Incorporated
- Rocky Mountain Energy Company
- Erda-Bendix Field Engineering Corporation
- John J. Simmons
- Gulf Mineral Resources Company
- Exxon Minerals Company, USA



The accident at the Three Mile Island nuclear power plant in Pennsylvania and the release of the movie *The China Syndrome* in 1979 brought uranium exploration to a standstill in the US.



Because neither the federal government nor the state of North Dakota had reclamation laws in effect at the time of uranium mining, more than 450 acres of uranium mine pits and spoils were left unreclaimed in Billings, Slope, and Stark counties in 1967. This photograph of the old unreclaimed Fritz Mine was taken 1986.

FRITZ MINE



The Fritz Mine (center of photograph) was reclaimed in 1992 with funds from the Abandoned Mine Lands Program of the North Dakota Public Service Commission.



A photograph looking north-northeast to the reclaimed Howie or Schwartz Mine that had been operated by GeoResources in Billings County. The mine was reclaimed in 1981.

GRIFFIN AND BELFIELD URANIUM ROTARY KILN SITES

The sites operated from 1964 – 1967.

In 1978, the Uranium Mill Tailings Radiation Control Act (UMTRCA) was created to cleanup inactive uranium processing sites and in 1979, the U.S. Department of Energy (DOE) developed the Uranium Mill Tailings Remedial Action project (UMTRA).

In 1979, the Belfield and Griffin sites were placed on the UMTRA list of sites to be cleaned up.

In the 1980s, the radioactivity and potential health risks of both of these sites were studied by DOE contractors.

The DOE studies concluded there are approximately 186,400 cubic yards of radioactive ash-contaminated soils between the two sites (31.7 acres containing 58,000 yd³ at Belfield and 71.1 acres containing 128,400 yd³ at Griffin).

There are no stockpiles of contaminated sediment at either site. The average depth of contaminated soil at Belfield is 1.1 feet and 1.2 feet deep at the Griffin site (DOE reports refer to Griffin site as the Bowman site).

GRIFFIN AND BELFIELD URANIUM ROTARY KILN SITES

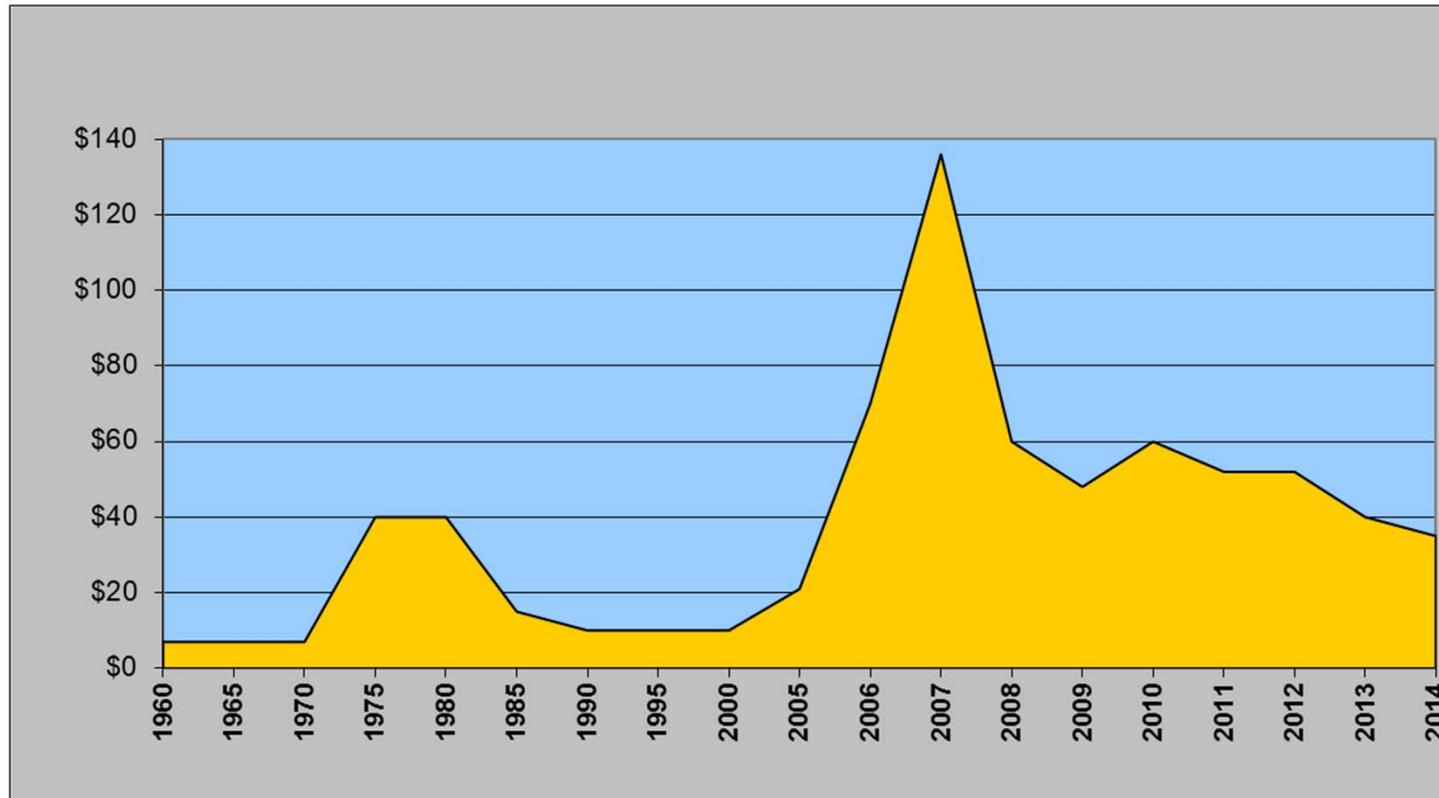
DOE concluded contamination was the result of the dispersion of the radioactive smoke and dust from the kilns as well as the spilling of radioactive ash during handling between the kiln and railroad cars. Radioactive dust and ash were further dispersed at these sites by wind and water. In addition, pore water in the unsaturated zone beneath the sites contained elevated levels of uranium and associated metals.

DOE proposed removing the 58,000 yd³ of contaminated soil from Belfield, hauling it to Griffin, and constructing a cell at the Griffin site that would hold all 186,400 yd³ of contaminated soil. Total cleanup was estimated at \$44.23 million (in 1995 dollars). Under UMTRCA, the state of North Dakota was responsible for 10% of project costs or \$4.423 million.

In 1995, the state of North Dakota requested both sites be dropped from UMTRCA because the state did not believe the low health risks the sites posed warranted the \$4.4 million the state would have to pay for their cleanup.

DOE agreed to remove the sites from UMTRCA in 1995 because; 1) the sites posed a low risk to the public and the environment, 2) North Dakota declined to pay the 10% cost share because of the low risk, and 3) neither the Nuclear Regulatory Commission nor the Environmental Protection Agency objected to the sites being taken off the list.

PRICE PER POUND OF YELLOW CAKE (U₃O₈)



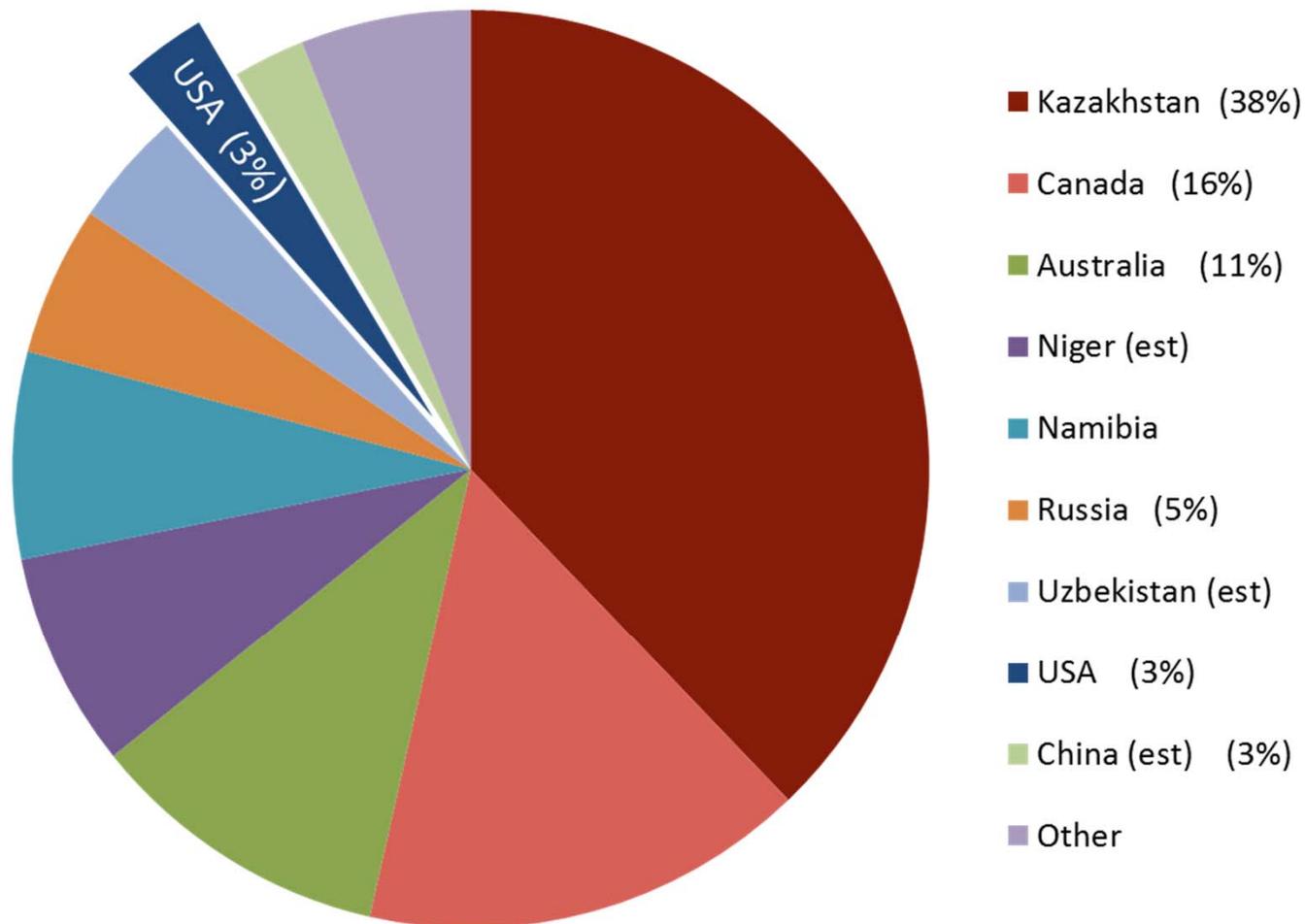
Throughout the 1960s the price for yellow cake was around \$7 per pound. The price hit \$40 in the 1970s while North Dakota was undergoing a surge in uranium exploration and dropped in 1979 as a result of the accident at the Three Mile Island nuclear power plant. The price for yellow cake peaked at \$134 per pound in 2007 as higher volumes of fuel generated from recycled nuclear warheads and uranium stockpiles averted a tightening of worldwide fuel stocks that had been predicted for nuclear power plants.



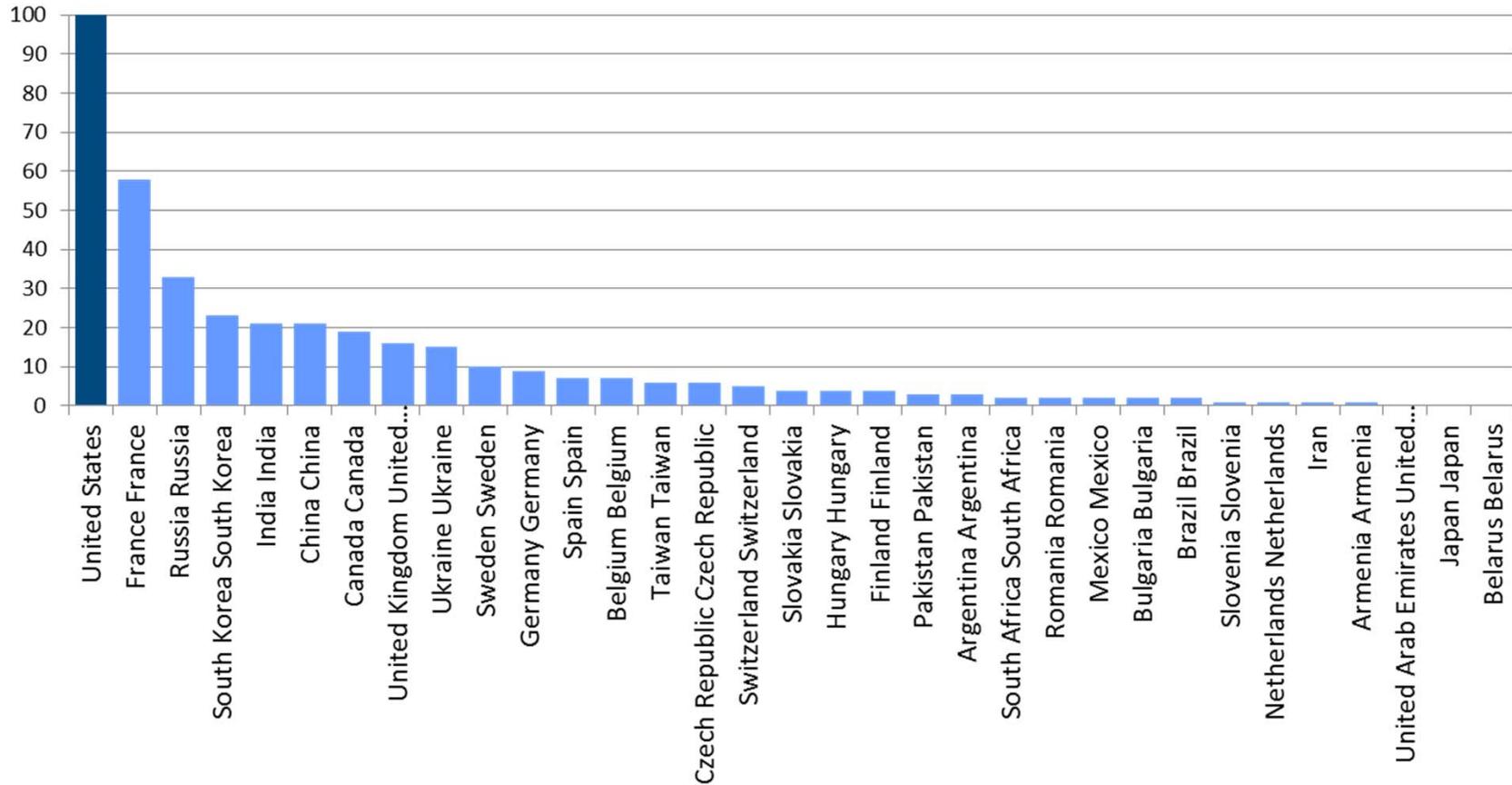
Formation Resources geologists collecting drill samples in an area just to the north of the old Fritz mine in Billings County. This 2008 photograph was taken looking to the southeast with West Rainy Butte in the background.

2013 URANIUM PRODUCTION

70,000 Tonnes of U_3O_8

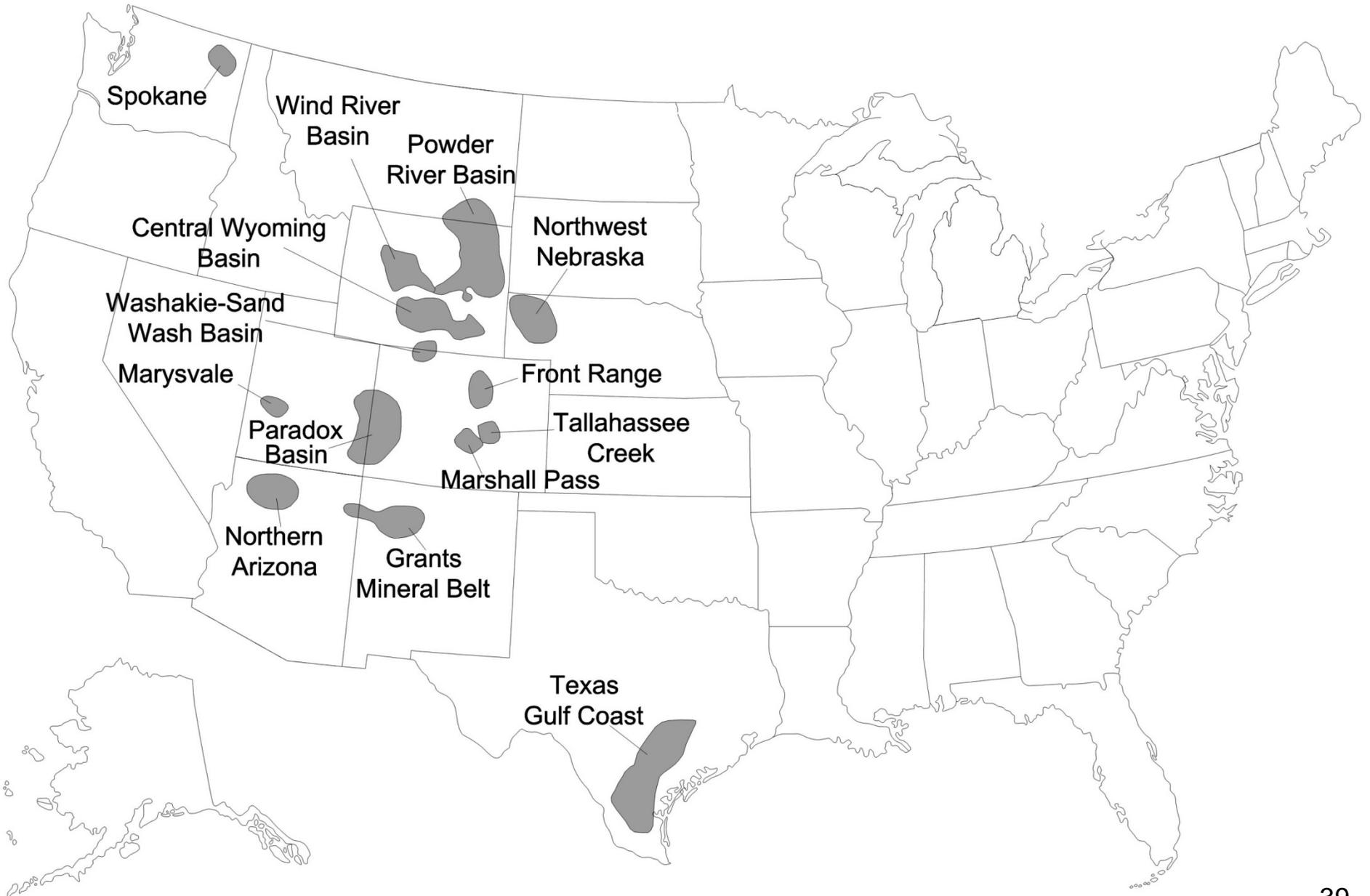


NUCLEAR REACTORS BY COUNTRY



The United States has 100 nuclear reactors, 26% of the operational reactors in the World. China has 21, with another 26 or so under construction.

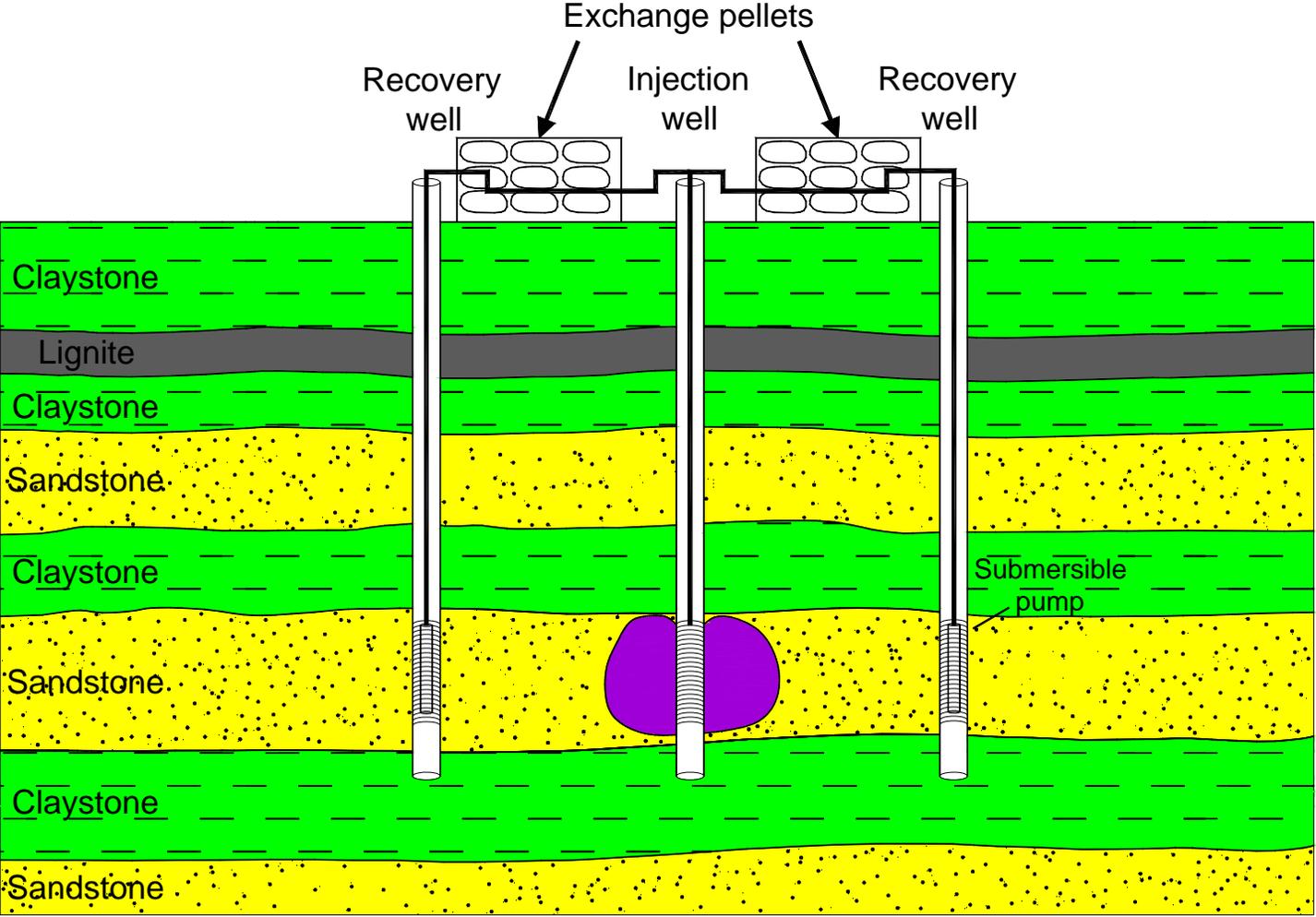
Major U.S. Uranium Reserves



URANIUM TIMELINE IN NORTH DAKOTA

1948	Uranium exploration begins in North Dakota.
1950s – 1960s	Uranium exploration continues, uranium test pits dug.
1962 - 1967	Uranium mining takes place in western North Dakota.
1968	Rules for Subsurface Minerals Program adopted (this program would have required uranium mine reclamation had mining not halted in 1967).
1976 - 1981	Companies drill 1,400 uranium exploration holes in North Dakota.
1980s	U.S. Dept of Energy evaluates Griffin and Belfield uraniumiferous lignite rotary kiln sites.
1980 -- 2004	North Dakota Public Service Commission Abandoned Mine Lands Fund pays for the reclamation of eight abandoned uranium mine sites involving 454 acres and costing approximately \$3.2 million.
2008	DMR-Geological Survey creates 58 pages of in situ leach uranium mining rules.
2008	Formation Resources, Inc. (PacMag Metals) drills 400 exploration holes in Slope and Billings counties looking for uranium, molybdenum, and germanium.

IN SITU LEACH URANIUM MINING

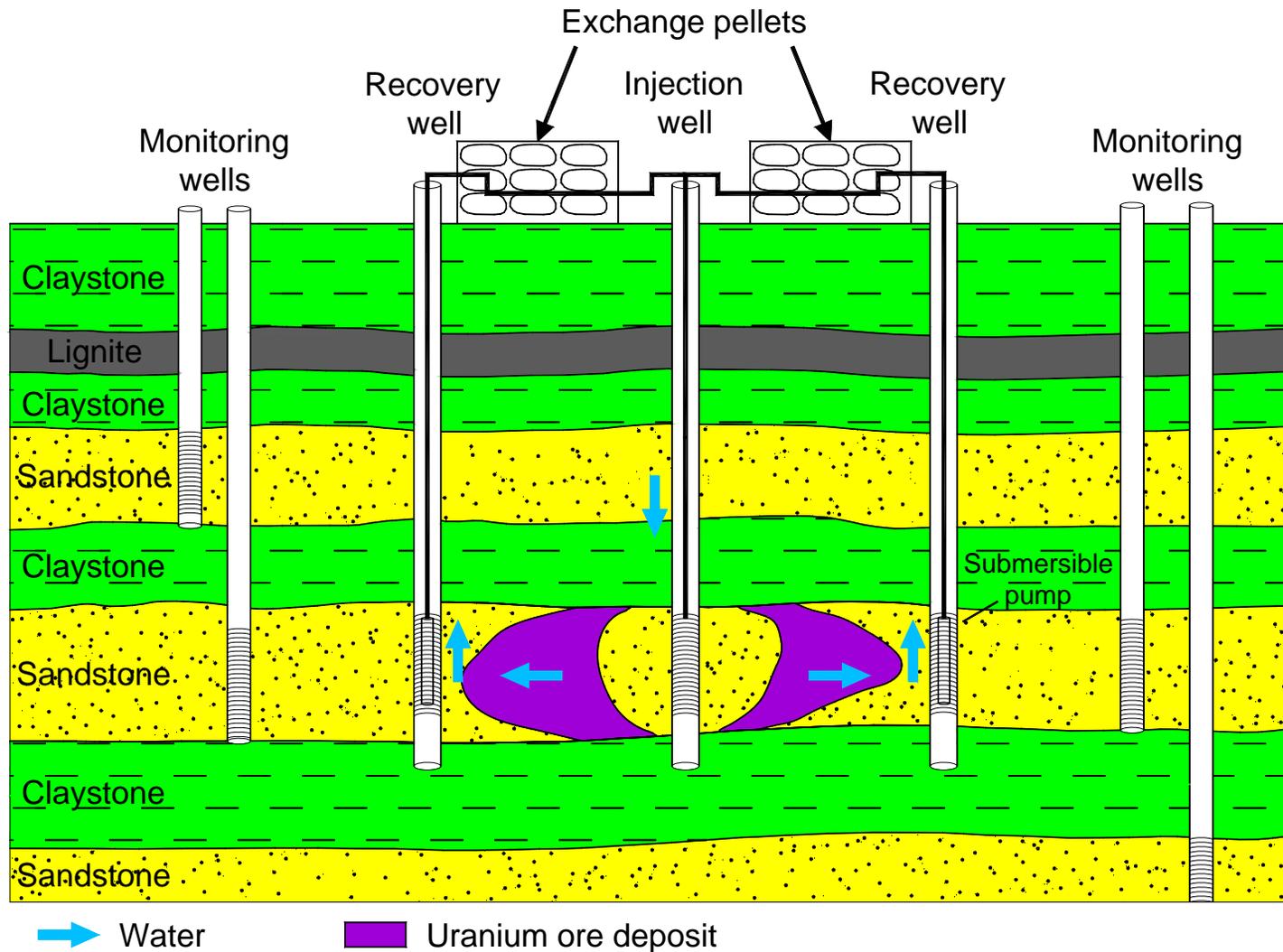


→ Water

■ Uranium ore deposit

IN SITU LEACH URANIUM MINING

Oxygen, hydrogen peroxide, or potassium permanganate, etc are added to the injected water to encourage uranium to go into solution.

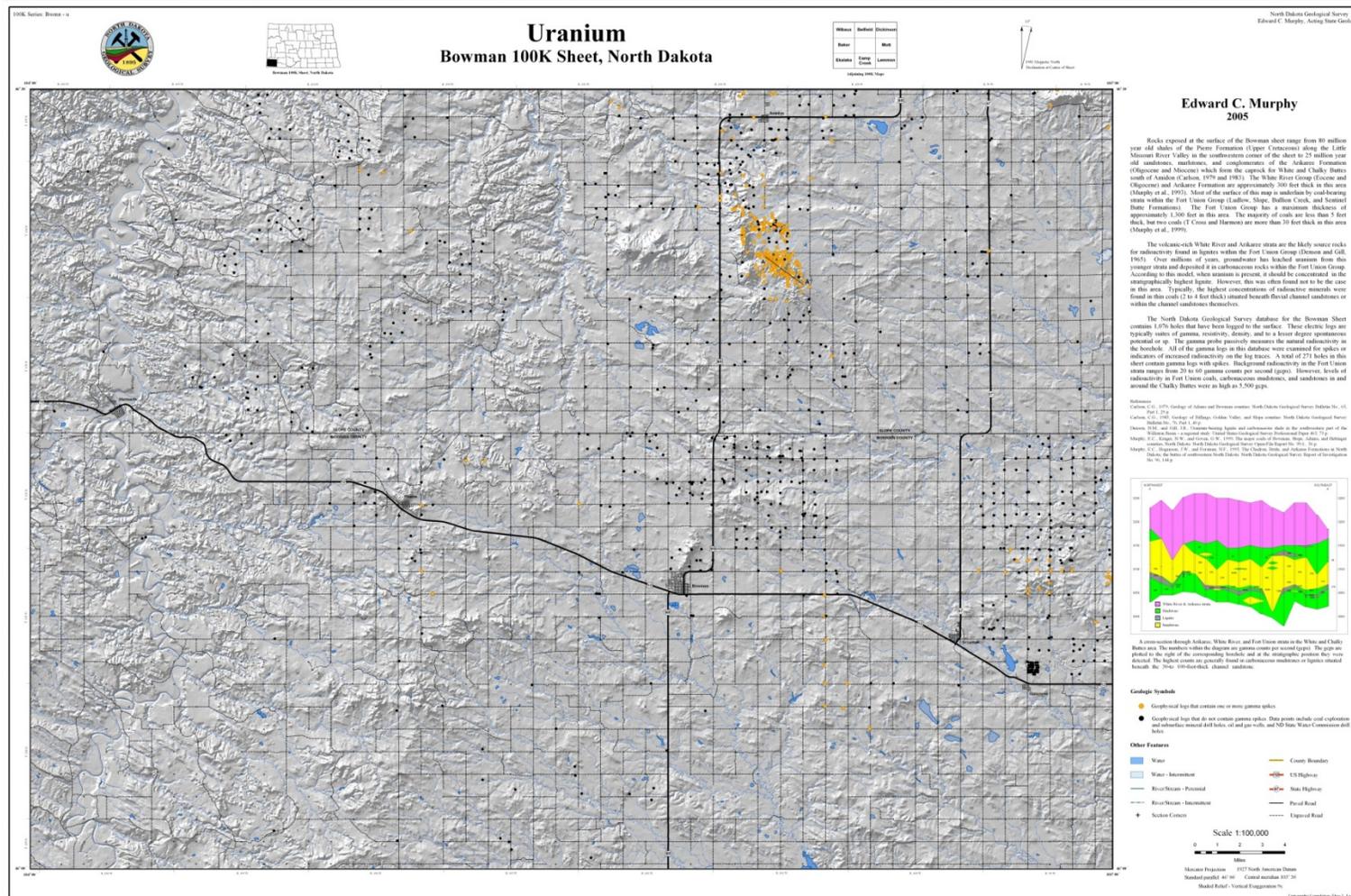




An in situ leach uranium well field at Cameco Corporation's Crow Butte operation near Crawford, Nebraska. Scientists from three North Dakota agencies (Dept of Mineral Resources, Public Service Commission, and Health Department) toured this site in 2007 so they would be better prepared to regulate ISL uranium mining if it were to come to North Dakota.

URANIUM RESOURCES IN NORTH DAKOTA

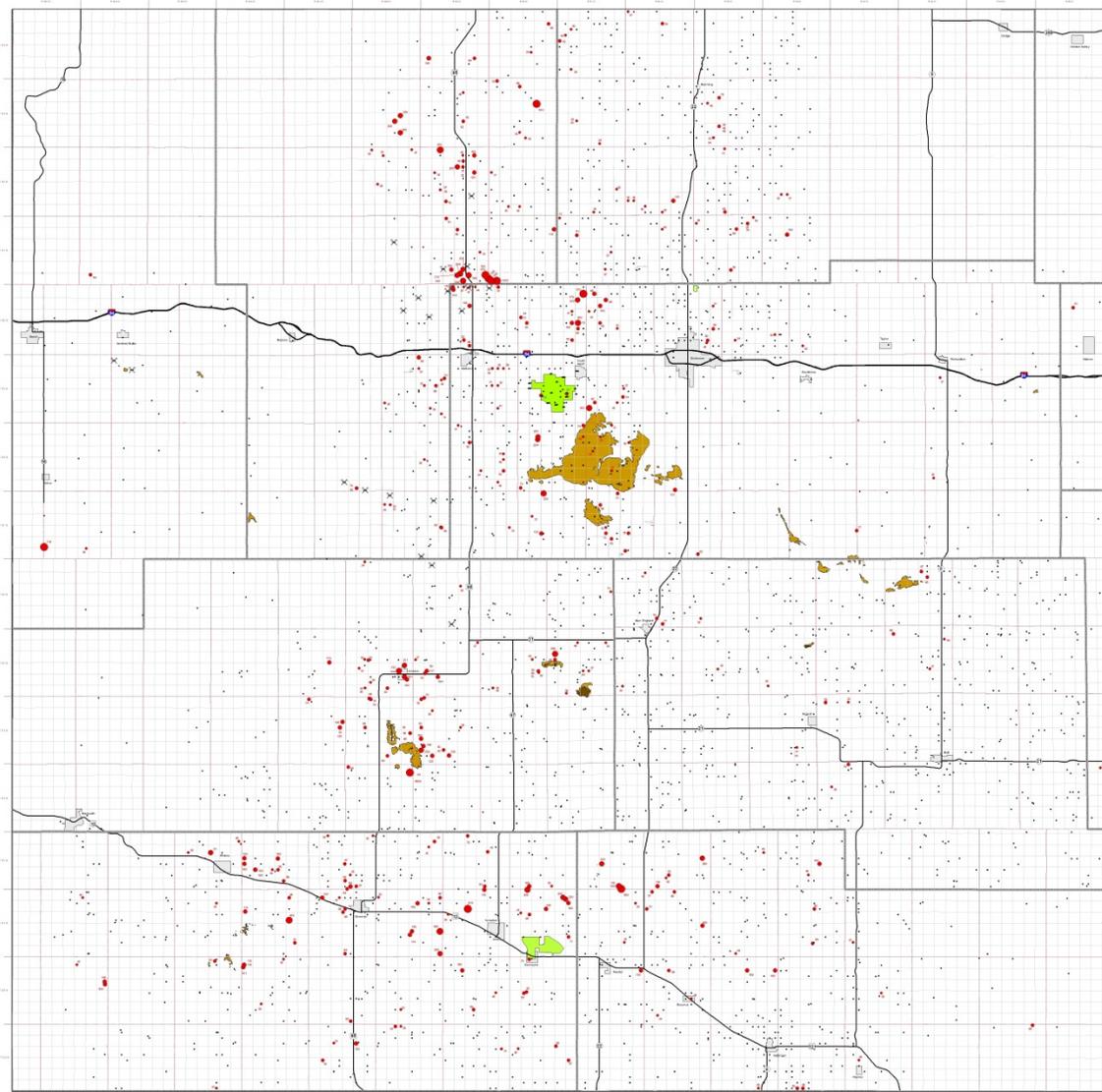
The North Dakota Geological Survey has published a number of uranium maps that can be downloaded for free from <https://www.dmr.nd.gov/ndgs/>
Slides 44 - 47 are examples of these publications.





Uranium Concentrations in Groundwater Southwestern North Dakota

Edward C. Murphy
2011



URANIUM CONCENTRATIONS
NRE and Bauer & Land (gpb) - Red Text
Great Northern Project Development (gpb) - Blue Text

• 0 < 30	• 200 < 300
• 30 < 50	• 300 < 400
• 50 < 100	• 400 < 500
• 100 < 200	• ≥500

GEOLOGIC SYMBOLS

■ ARKAREE FORMATION
■ WHITE RIVER GROUP
□ GEOLOGY UNDIFFERENTIATED
× Approximate Location of Abandoned Uranium Mine

Scale 1:250,000

North Arrow

Map Date: 07/10/11
Scale: 1:250,000
Graphic Scale: 07/10/11

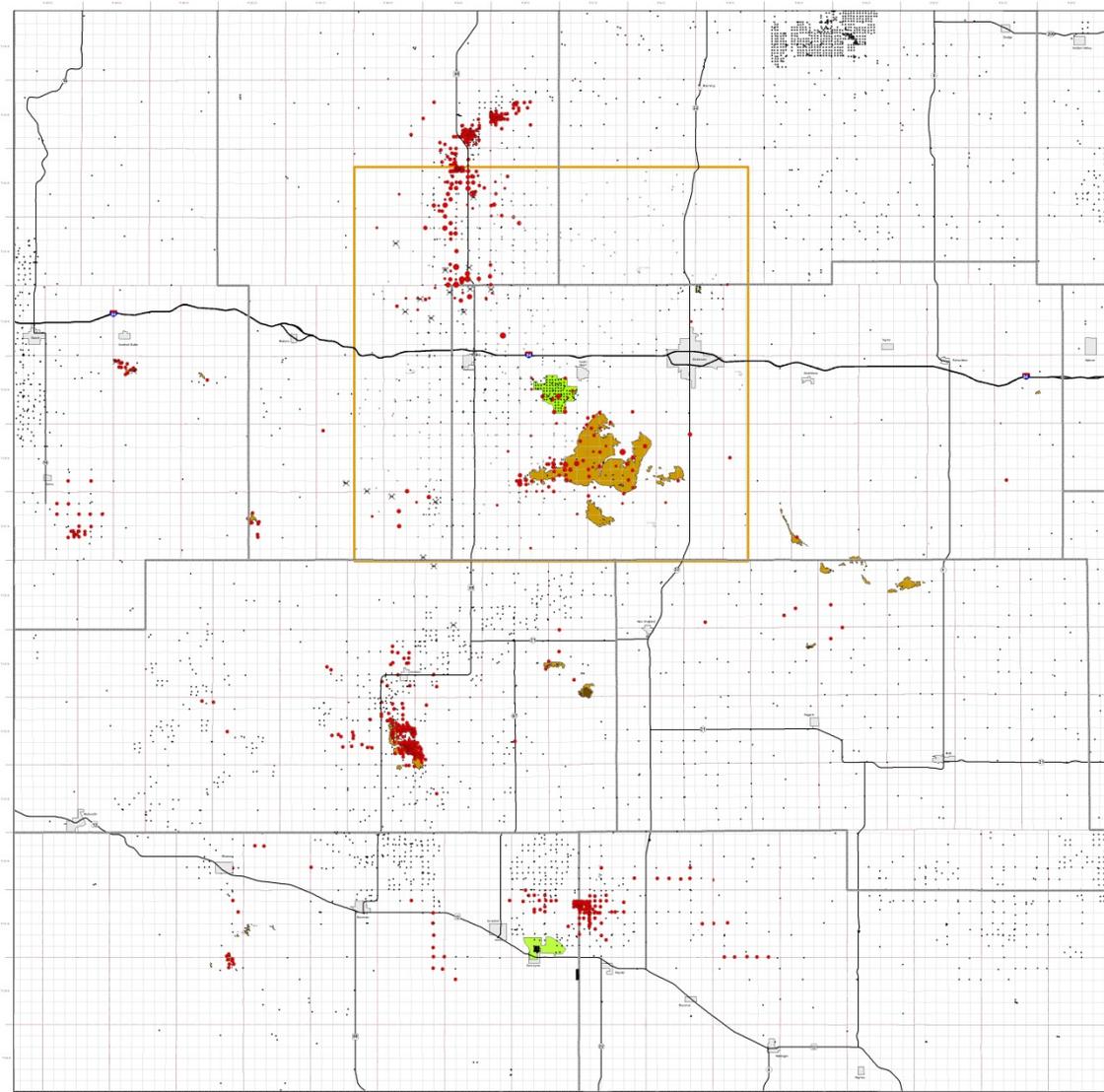
MISC SYMBOLS

■ Proposed South Heart Mine	— County Boundary	• Town
■ Glasco Mine (closed)	— Township Boundary	— Interstate Highway
■ S. Ranch Mine (closed)	— Section Boundary	— US Highway
	— City Boundary	— State Highway



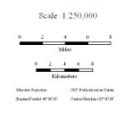
Spikes on Gamma Ray Logs Southwestern North Dakota

Edward C. Murphy
2011



- LEGEND FOR QUANTIFIED AREA**
- CPS (Counts Per Second)
 - Gamma Ray Logs with Spikes ≥ 1,000 CPS
 - Gamma Ray Logs with Spikes 500 - 999 CPS
 - Gamma Ray Logs with Spikes 200 - 499 CPS
 - Gamma Ray Logs with Spikes 100 - 199 CPS
 - Gamma Ray Logs with Spikes < 100 CPS
 - Gamma Ray Logs without Spikes
 - Data Point Could Not Be Verified

- LEGEND FOR AREA OUTSIDE QUANTIFIED AREA**
- Gamma Ray Logs with Spikes
 - Gamma Ray Logs without Spikes
 - Gamma Ray Logs Quantified



- GEOLOGIC SYMBOLS**
- ARKAREE FORMATION
 - WHITEVEVER GROUP
 - GEOLOGY UNDIFFERENTIATED
 - × Approximate Location of Abandoned Uranium Mine

- MISC SYMBOLS**
- Proposed South Heat Mine
 - Gascoite Mine (closed)
 - J.K. Ranch Mine (closed)
 - County Boundary
 - Township Boundary
 - Section Boundary
 - City Boundary
 - Town
 - Interstate Highway
 - US Highway
 - State Highway