Environmental Impacts from Wind Erosion of Abandoned Mine Lands

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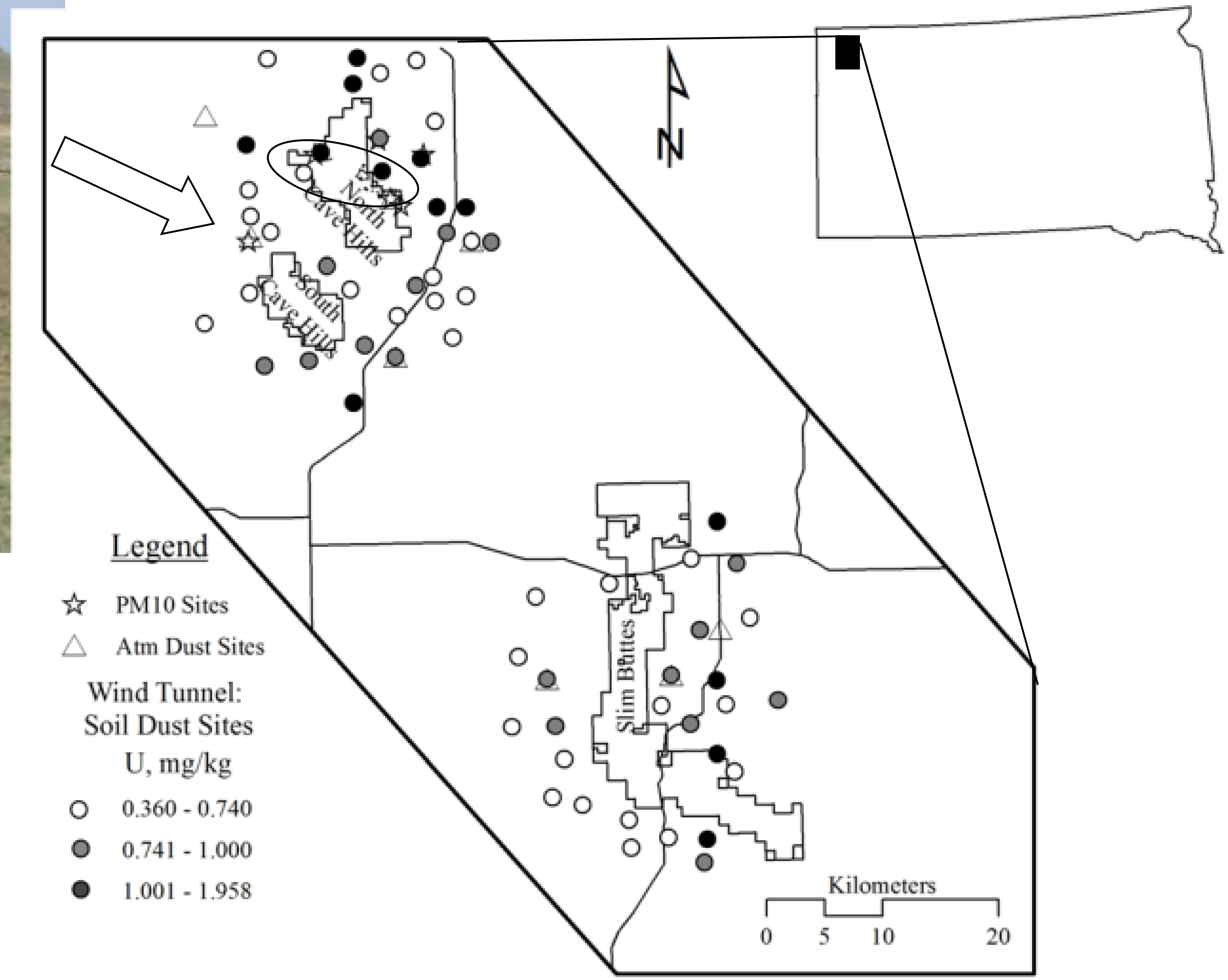
A *Joint Venture* between the US Forest Service and South Dakota School of Mines & Technology



~1000 Sq. Km Research Area

Flat topped timbered ridges

Sandstone cliffs

320 disturbed acres on FS land

Uranium-bearing lignite

Ore-grade (0.1%+) within Lonesome Pete seam of Tongue River; and seams within Ludlow Formation

738,000 lbs U_3O_8 produced in Harding Co.

Tertiary Fort Union Formation

Tongue River Member: *fine-grained yellow sandstone; interbedded shale, siltstone, claystone, and uraniferous lignite*

Ludlow Member: *Underlying sandstone, shale, uraniferous lignite*

AUMS Dust Transport Study

OBJECTIVES:

1) Determine *offsite impacts* originating from abandoned uranium mining activities onto private lands from *wind* transported dust

2) Determine the levels, if any, of naturally-occurring heavy metals and radionuclides in dust within the defined study area

3) Assess source of contamination, if any exists

Radiological Hazards

Potential hazardous characteristics of uranium mine waste:

1) elevated radioactivity emanations as gaseous isotopes of radon,
2) elevated radiation in the vicinity of the mine sites,
3) heavy metals migration and contamination to soil, surface, and ground water.

From a human health standpoint, contaminated PM particles small enough to settle in the bronchi and lungs could lead to adverse health conditions including development of:

1) irradiated lung tissue and radiation injury in the respiratory tract
2) tumor
3) atrophy of functional tissue
4) increased susceptibility to other disease agents

External radiation effects related to dust particle deposition on skin and in eyes. Both considered minor with respect to those of respiratory tract

Effects of PM inhalation have been widely studied in humans and animals and include asthma, lung cancer, cardiovascular issues, and even premature death

Radiological Mechanisms

- The main determinant of location of particle deposition in the respiratory tract is particle size
- Larger particles are generally filtered in the nose and throat
- Particles smaller than ~10 micrometers, PM_{10}, settle in the bronchi and lungs
- The 10 micrometer size does not represent a strict boundary between respirable and non-respirable particles
- Particles smaller than 2.5 micrometers, $PM_{2.5}$, tend to penetrate into the gas-exchange regions of the lung
- Very small particles (< 100 nanometers) can pass through the lungs to affect other organs
  - Evidence suggests these very small particles can pass through cell membranes

Sampling Methods

Wind Tunnel: 32 locations, 8 minute run time, 4 minutes at 30 mph, 84 minutes at 44 mph

Skimmed Soil: 44 locations where wind tunnel access was denied. Sample collected from the surface dust using a stainless steel scoop

Ambient Dust: 8 locations that utilized an elevated sampler to collect dustfall

PM_{10}: 6 locations where a high-volume PM_{10} sampler was used

Analytes

Analyte Name	Chemical Symbol	DL (mg/kg)
Arsenic	As	0.5
Copper	Cu	0.5
Lead	Pb	0.5
Molybdenum	Mo	0.5
Selenium	Se	0.5
Thorium 232	Th	0.5
Uranium	U	0.5
Vanadium	V	0.5

Analytical work at SDSMT, private lab, and US EPA lab

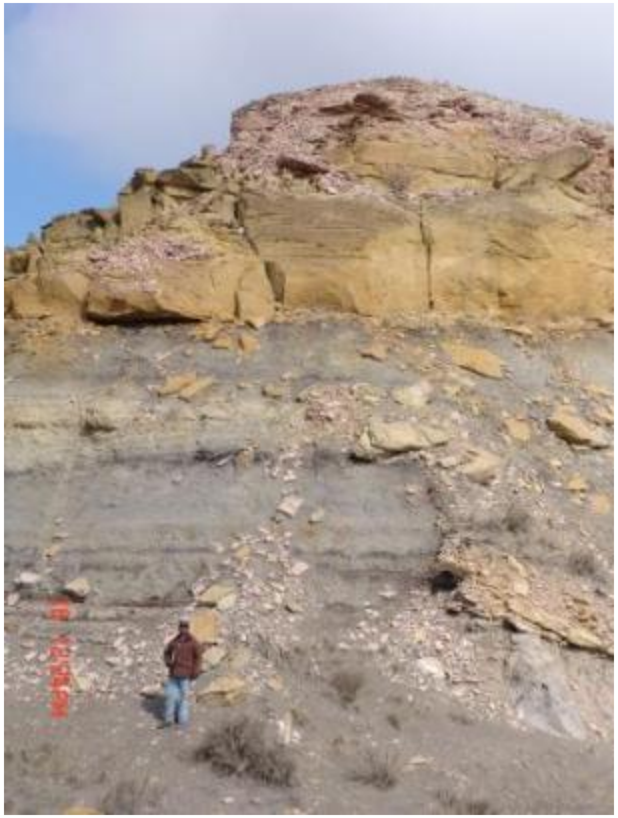
Natural Radiation Emitters

Rock Type	Radium		Uranium		Thorium		Potassium	
	Ra-226 pCi/g	Ra-226 Bq/g	U-238 pCi/g	U-238 Bq/g	Th-232 pCi/g	Th-232 Bq/g	K-40 pCi/g	K-40 Bq/g
Igneous	1.30	48.0	1.30	48.0	1.30	48.0	22.0	810.0
Sandstone	0.71	26.0	0.40	15.0	0.65	24.0	8.8	330.0
Shale	1.08	40.0	0.40	15.0	1.10	41.0	22.0	810.0
Limestone	0.42	16.0	0.40	15.0	0.14	5.1	2.2	81.0

All results ultimately converted to pCi/g (U^{238} = 0.33 and Th^{232} = 0.28 pCi/g)
Compared to average U^{238} and Th^{232} concentrations in common rock types.

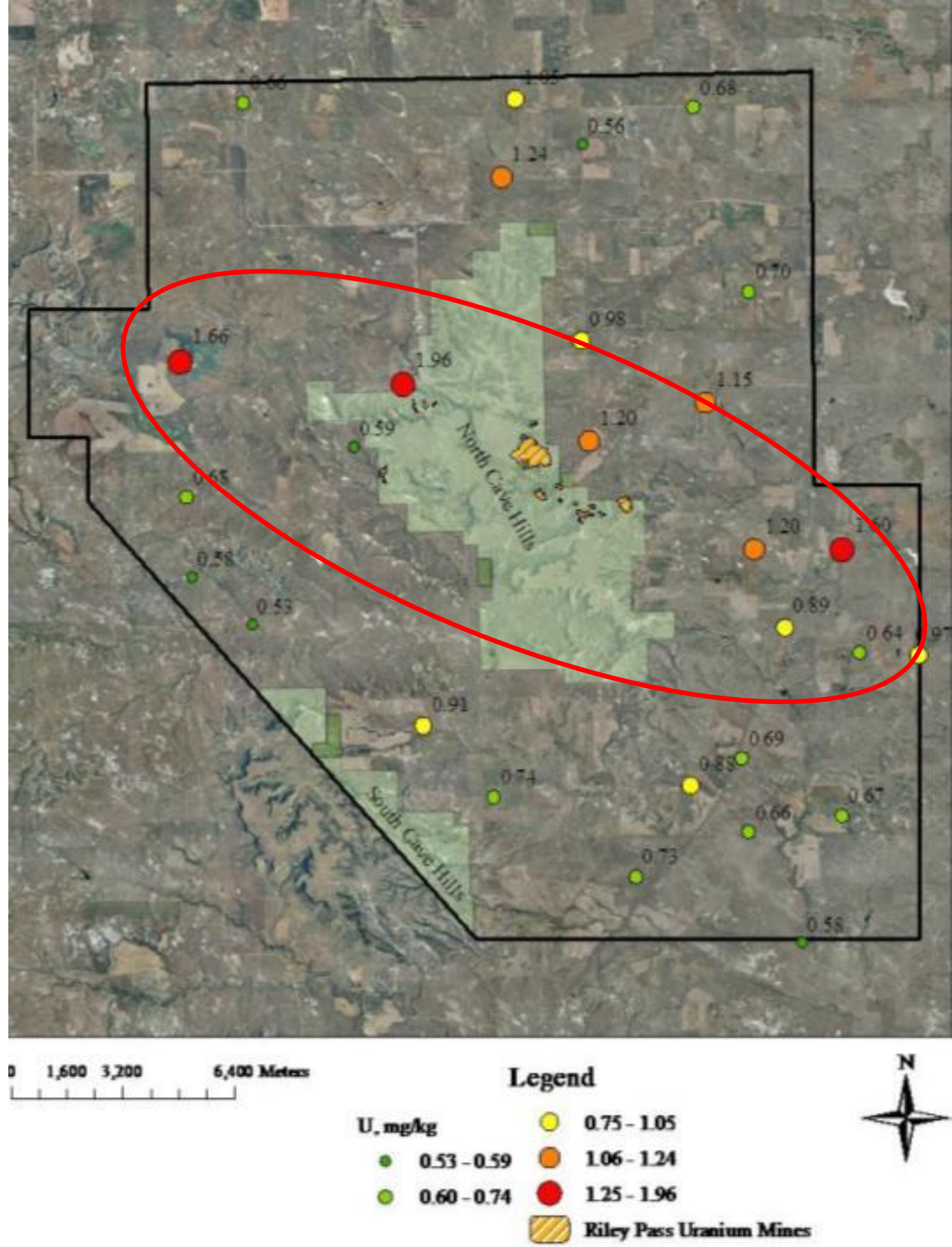
Study are consisted of sedimentary rocks, predominantly sandstone and shale with interlayers of coal and siltstone

Native soil would have been derived from weathering of these sediments



Wind Erosion Results

- Natural background U concentration was 0.74 mg/kg
- 34 location >background with average of 1.09 mg/kg
- Sediment core background was 22 mg/kg



Ambient Dust Results

Eight sites across 1,000 Km^2

Thirty-three samples analyzed

No background value

Thirty-five analysis over a 2 year period

Five U values

	Arsenic	Lead	Molybdenum	Selenium	Uranium	Vanadium	Thorium 232	Copper
Sample ID				mg/kg				
NCH-AD-1-1	2.31	19.22	1.01	2.58		2.09	0.61	26.59
NCH-AD-1-4	4370	306	4.6		1.4	66	9.1	96
NCH-AD-1-5	452	34	2.3	0.54		10	0.8	67
NCH-AD-2-1	5.15	3.87	7.83	8.81	0.54	0.97		46.27
NCH-AD-2-1 DUP	4.60	5.20	15.00	13.00	0.42	1.30	0.35	62.00
NCH-AD-2-2	2.09	3.26	3.70	5.38		0.77		33.24
NCH-AD-2-5	902	69	19	9.9	0.9	13	2.2	59
NCH-AD-2-6	22	5.4	4.3	3.2		5.4		15
NCH-AD-3-1	2.01	3.99	1.45	3.35		1.53		24.45
NCH-AD-3-4	36	19	1.4	2.9		10	0.89	22
NCH-AD-3-5	2450	183	0.97			49	9.1	25
SB-AD-DNM-1	6.9	14		9.2		3.5	0.56	11
SB-AD-DNM-2	293	47	1.6			17	2.6	61
SB-AD-DNW-1	41	43	1.5	7.4		10	1.8	30
SB-AD-DNW-2	16100	102	19	3.2	13	227	0.5	18800
SB-AD-UPV-1	27	71	3.1	3.8		13	0.74	57
SB-AD-UPV-2	155	55	2	4.6		22	3.7	51
SCH-AD-DNT-1	43	80	1.6	3.7		10	1.6	39
SCH-AD-DNT-2	69	22	0.73	2.3		2.5	0.54	52
SCH-AD-UPJ-1	1030	90	7.9	5.5		19	2.7	85
SCH-AD-UPJ-2	27	34	1	3.8		18	2.5	34

PM_{10} Dust Measurements

PM_{10} Results

No filter sample had a detection above instrument detection level of 0.5 mg/kg

Each analysis had an estimated, or analytical, value that was used to calculate U concentrations had the mass on the filter been sufficient to produce an analysis

Filter ID No.	Dust Mass gm	Analytical Value mg/filter	U mg/kg
7815100	0.029	0.00102	0.02835
7815099 (control)	1.0	0.00357	3.57035
7815098	NOT USED IN ANALYSIS		
7815097	0.009	0.00060	0.00515
7815096	0.025	0.00860	0.20886
7815095	0.045	0.00926	0.39861

The Occupational Safety and Health Administration (OSHA) sets inhalation standards for work-related resparable dusts in 29 CFR 1926.55 which specifies a uranium on dust standard of **0.2** mg/m^3 of air.

U Concentration

Equivalent mass concentration of uranium was calculated as 0.00926 mg.
Sampling time = 23 hours.
Average equivalent mass concentration per m^3 of air would be:

$$0.00926mg \Big/ 1{,}562m^3 = 5.9E^{-6}\,\frac{mg}{m^3}$$

This value is ~4 orders-of-magnitude less than the OSHA uranium standard of 0.2 mg/m^3.

Conclusions

- No supporting data to indicate aeolian processes as a mechanism of contamination dispersal
- If soil dust originated from the AUMS, wind dispersal has reduced U concentrations to a value far less than 30 times that of soil
- No definitive data existed to link U detections to AUMS
- No PM filter sample analysis contained a detection of contaminant metals;
- Aerosol PM10 uranium concentrations are five times less than uranium concentrations on surface dusts which are seven times less than those for soils;
- Calculations based on analytical data indicate PM uranium concentrations are four orders-of-magnitude less than the OSHA uranium standard for dust of 0.2 mg/m3.

Based on the above data and supporting calculations, these results suggests that uranium concentration on aerosol dusts is very low and does not constitute a negative human health impact