North Dakota Geological Survey

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https://www.dmr.nd.gov/ndgs/

August 22, 2011

Mr. James R. Deutsch
Director, Reclamation Division
North Dakota Public Service Commission
Bismarck, North Dakota 58505

RE: Review of Whole Rock Acid Digestion Data in South Heart Coal, LLC's Mining Permit SHSH-1001

Dear Mr. Deutsch:

I have completed my review of the whole rock analytical data that Great Northern Project Development submitted in support of their mine permit application for the South Heart area. I concentrated my efforts on uranium, arsenic, and molybdenum because they are often found in close association. I completed my review on July 8, but delayed submitting it until I could track down a 1982 report the Bendix Corporation submitted to the U.S. Department of Energy regarding the National Uranium Resource Evaluation of the Dickinson Quadrangle. Last Friday, I received a version of that report through the National Technical Information Service. Unfortunately, it did not include the appendices and the raw data that I was looking for.

Please contact me if you have any comments regarding the attached review.

Sincerely,

Edward C. Murphy
State Geologist

encl.

Review of South Heart Coal, LLC's Mining Permit SHSH-1001

Whole Rock Analysis Addendum

August 22, 2011

Edward C. Murphy
North Dakota Geological Survey

Great Northern Project Development included a whole rock analysis table in their mine permit application for the South Heart area (Table 2.3-12). The detection limits for uranium, arsenic, and molybdenum (>10 mg/kg) were set too high for any discernable patterns to be identified within this group of 35 whole rock analyses. That is, the vast majority of analyses for all three parameters were below the detection limits. On May 17, 2011, Great Northern Project Development submitted additional whole rock analysis in support of their permit application (it was labeled Attachment A). The detection limits were much lower for this second batch of 124 samples, down to 0.59 mg/kg for arsenic, 1.5 mg/kg for uranium, and 0.25 mg/kg for molybdenum. As noted by the company, this round of analyses targeted lithologies, stratigraphic settings, and hydrologic settings where conditions might be favorable for the concentration of uranium and other trace metals. To this end, the company analyzed a number of samples that were collected at, or across, the contact between sandstone and underlying lignite, including the "D" coal. To evaluate these results, the ND Geological Survey plotted analyses on paper copies of the lithologic descriptions of the boreholes. Groundwater analyses and the spikes on the gamma ray logs had previously been plotted on these borehole descriptions, enabling a comparison of all three results. Uranium, arsenic, and molybdenum were focused upon because they are often found in close association within the Fort Union Group.

Analyses were reported for 38 samples that had been collected at the interface between the top of the "D" coal and overlying sandstone or siltstone. Ignoring the first round of samples (detection limit of < 10 mg/kg), the highest recorded uranium value at this stratigraphic horizon was 2.4 mg/kg. If you assume the worst case scenario i.e., that the concentration was equal to the detection limit for the second round of sampling, the average uranium concentration at this horizon is 1.8 mg/kg. Arsenic levels at this stratigraphic horizon ranged from 1.4 to 26.9 mg/kg, with an average concentration of 8.4 mg/kg. It is anticipated these concentrations decrease vertically through the "D" coal, as is typical of other thick coals in western North Dakota.

Because the source of the uranium (and most other trace metals) was the stratigraphically higher White River and Arikaree rocks, the uranium and arsenic values, as a whole, typically decrease in concentration with depth in Fort Union strata. As a result, the highest uranium concentrations are often found in the stratigraphically highest coals. This holds true in SHOB-104R and in SHOB-143R where a thin (2.5 feet thick) shallow (10 feet deep) coal has uranium concentrations of 7.2 mg/kg (and arsenic concentrations of 20 mg/kg).

Multiple samples were collected in a number of boreholes enabling a vertical evaluation. Uranium and arsenic concentrations generally decreased with depth in holes SHOB-8R, SHOB-9R, SHOB-17R, SHOB-23R, SHOB-41, SHOB-45R, and SHOB-141. This pattern would be expected in most of the other holes and might have been discernable had more than one sample

been analyzed. On the other hand, concentrations did not follow this pattern in holes SHOB-12R, SHOB-101R, and SHOB-103R because of variations in concentrations between organic-rich beds (such as coals) and nonorganic-rich beds (such as clean claystones and mudstones).

Hole number SHMW-04 was unique in that eleven samples were analyzed within the top 70 feet of the hole. Unfortunately, seven of these were from the first batch of samples (detection limits below 10 mg/kg) so no distinct patterns were discernable. Five consecutive samples were analyzed across an interval from 5 to 25 feet in hole number SHOB-41. A shallow, thin coal and claystone in this hole have some of the highest uranium values recorded by whole rock analysis (4.2 and 10 mg/kg). These values correspond stratigraphically to spikes on the gamma ray logs enabling a comparison between the two. The arsenic values are also high in these horizons ranging from 19 to 35 mg/kg. This appears to be the only hole where a gamma spike and whole rock analysis coincided.

These analyses confirm the observations of earlier scientists regarding uranium and arsenic in Fort Union strata. Typically, when arsenic increased in concentration within a given borehole, uranium also increased. In general, arsenic and uranium concentrations were higher in the near surface and decreased in concentration with depth.

The average uranium analysis for all of the samples analyzed in the second round was 2.2 mg/kg (Table 1). Again, this number should be viewed as a maximum limit because the " < " was changed to " = " before the averages were calculated. These numbers are also skewed upwards because the majority of analyses (65%) came from geologic settings where uranium and other trace metals would be expected to be concentrated. The arsenic concentrations for this second round of analyses had an average concentration of 11.1 mg/kg with a high of 83.8 mg/kg. Molybdenum had an average concentration of 1.8 mg/kg and a high of 13.5 mg/kg.

The results of the Great Northern Project Development whole rock analysis were compared to two existing databases. The U.S. Geological Survey's National Geochemical Database contains analyses of 376 Fort Union rock samples from western North Dakota. Unfortunately, uranium and arsenic concentrations were not reported for the vast majority of these samples. The uranium content for the only sample listed in Stark, Dunn, Hettinger and Slope counties was 6.6 ppm, the molybdenum content of 59 rock samples from these counties was also 6.6 ppm, and no arsenic analyses were reported (Table 1). Under the National Uranium Resource Evaluation (NURE) project, 555 stream-sediment samples (surface samples) were collected in southwestern North Dakota, including the area of the proposed South Heart coal mine. These stream-sediment samples had an average uranium concentration of 2.8 ppm and an average arsenic concentration of 4.7 ppm. Seventy-two percent of the molybdenum concentrations were reported below the 4.0 ppm detection limit. The average molybdenum concentration was 4.3 ppm when those values were set to the detection limit (Table 1). It should be noted that milligrams per kilogram (mg/kg), the unit of measurement for the rock analyses submitted by Great Northern Project Development, are roughly equivalent to parts per million (ppm).

Most significantly, the average concentrations for the uranium analyses reported by Great Northern Project Development (GNPD) for alluvium and Fort Union rocks is less than the average concentration of the surface-sediment samples collected by NURE (2.2 vs 2.8 ppm). The average concentration of molybdenum in the GNPD samples is also less than the average of the NURE sediment samples (2.8 vs. 4.3 ppm). This may be due, in part, to the NURE molybdenum average being heavily skewed upwards (72% of the analyses were below the detection limit, but set to the detection limit when the average was calculated). On the other hand, the average arsenic concentrations in the GNPD samples are higher than the NURE samples (11.1 vs 4.7 ppm).

Table 1. Comparison of Great Northern Project Development Whole Rock Analysis Averages (second round) to Other Database Averages.

	Uranium		Arsenic		Molybdenum	
	# Samples	Concentration	# Samples	Concentration	# Samples	Concentration
Great Northern Project Development (GNPD)	124	2.2*	124	11.1	124	1.8
USGS National Geochemical Database (rocks)	1	6.6	0	NV	59	6.6
NURE (stream-sediment)	555	2.8	555	4.7	555	4.3*

* Concentrations less than the detection limit were set to the detection limit.
NV No value reported
GNPD concentrations in mg/kg, NURE and USGS in ppm

According to the World Nuclear Association, the average uranium concentration for sedimentary rocks is 2 ppm. The average uranium concentrations of the GNPD samples are very close to this average (2.2 vs. 2.0 ppm) even though the South Heart numbers are skewed upwards as previously noted (Table 1).

The National Academy of Science (1977) reported average arsenic values for sedimentary rocks of 2 ppm for sandstone, 13 ppm for coal, and 14.5 ppm for clay and shale. Based upon those values, the 11.1 mg/kg average arsenic concentration of GNPD sediment and rock samples at the proposed mine site appears to be within the normal range.

Molybdenum ranges from 0.2 to 100 ppm in sedimentary rocks: 0.2-0.4 ppm in sandstone, 2 ppm in clays and shales, and 100 ppm in organic-rich (carbonaceous) rocks (Aubert and Pinta, 1977, Trace Elements in Soils). The average molybdenum concentration in Quaternary sediments and Fort Union rocks at the proposed South Heart mine site (1.8 ppm) falls well within this normal range.