Multi-Sensor Core Logger Analysis of Bechtold #1 Drill Core (API # 15-013-20009)

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Energy & Stratigraphy

Kansas Geological Survey

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Drill Core Identifying Information and Analysis Parameters

LEASE: Bechtold
WELL # 1
KID # 1002887925
API # 15-013-20009
Project: RII Track-2 FEC: Critical Resource Availability for the Future of the Renewable Energy Industry: Critical Minerals and Ground Water Resources in Iowa and Kansas
Date(s) Analyzed: 12/10/2024
Diameter: 3.35 in. (PQ)
Geometry: Whole core
pXRF mode: Geochem (3-Beam) on Vanta M-Series
Geochemical reference materials: OREAS 463, SCo-2, STM-1
Analysis Interval: 10 cm

Sensor Count Times (sec)
Density: 30
Magnetic Susceptibility (4.75 in. loop sensor): 10
Gamma Ray: 120
pXRF (per beam): 45

Completion date of data processing: 04/22/2026
Data processed by: Rachel L. Smith (kgs-enstrat-lab@ku.edu)

All dates are in MM/DD/YYYY format.
All depths reported are initial core depths, and no depth shifts have been applied.

Acronyms, Abbreviations, and Symbols	
Term	**Description**
API	American Petroleum Institute units
GRM	Geochemical reference material
KGS	Kansas Geological Survey
LOD	Limit of detection
MSCL	Multi-Sensor Core Logger
PRM	Petrophysical reference material
pXRF	Portable X-ray fluorescence spectrometer
RSD	Relative standard deviation
Vp	P-wave velocity
Vs	S-wave velocity

1. MSCL Overview

This report provides an overview of the Bechtold #1 Multi-Sensor Core Logger data acquisition methodology and data quality assessment. The Geotek Ltd. Multi-Sensor Core Logger (MSCL) at the Kansas Geological Survey (KGS) is equipped with seven sensors and a high-resolution line scan camera (up to 1,000 pixels per cm over the full core width). The sensors obtain the following data types: density, P- and S-wave velocity (*Vp*, *Vs*), impedance, core thickness, magnetic susceptibility, natural gamma (API, spectral potassium, uranium, thorium), visible and near-infrared light (VNIR), short wavelength infrared light (SWIR), and bulk surface geochemistry (pXRF). Magnetic susceptibility data are obtained using a Bartington MS2E (point) or MS2C (3 in. or 4.75 in. loop) core logging sensor. Bulk geochemistry is collected using an Olympus Vanta M-Series portable X-ray fluorescence spectrometer (pXRF). The spectrophotometry (VNIR, SWIR) data are collected by a Malvern Panalytical LabSpec 4 Hi-Res Analytical Spectral Device (ASD). The KGS has three scintillation detectors on its MSCL, allowing for lower natural gamma analysis count times. The natural gamma, density, sonic (*Vp*, *Vs*, impedance), and core thickness sensors were developed by Geotek Ltd. An in-depth explanation of the function of these sensors can be found in the Geotek MSCL-S Manual (Geotek Ltd., 2023). The MSCL is a semi-quantitative analytical instrument capable of acquiring a variety of data types at a high sampling resolution. These data are best suited for observing relative trends within the core and identifying areas of interest for further sampling.

2. Calibration

Density is recalibrated at the beginning of each new core project and at the beginning of every week thereafter (if necessary). The factory calibration of the magnetic susceptibility sensor is checked weekly, while a factory calibration check (CalCheck) of the pXRF is performed at the beginning of each core project. The magnetic susceptibility results are recorded and tracked over time. The spectrophotometer is calibrated daily on Spectralon. The sonic sensors do not require calibration (Geotek Ltd, 2023). The natural gamma API (American Petroleum Institute units) calibration and ambient background radiation measurements are performed at the beginning of each new core project. API calibrations are conducted using Geotek's custom-made petrophysical reference materials (PRM). These PRM are 30-cm-long sections of granite, dolomite, and slate (fig. 2). Geotek produces PRM for the following core diameters: 1.87 in. (NQ), 2.5 in. (HQ), 3 in., 3.35 in. (PQ), 4 in., and 5.25 in. At the beginning of each core project, the set of PRM closest to the diameter of the project core is chosen. The natural gamma detectors' energy calibration is evaluated for drift weekly by counting for 5 minutes on the International Atomic Energy Agency (IAEA) Potassium Sulfate (IAEA-RGK-1) and Thorium Ore (IAEA-RGTh-1) reference materials and recalibrated as needed (>2% difference from expected

values). The natural gamma background radiation measurement also is checked weekly to ensure it is below approximately 50 counts per second.

3. Procedure

Each day, all sensors are tested to ensure the MSCL is fully functioning. Next, the reference core thickness (RCT) point is measured on the slate PRM and the spectrophotometer is calibrated. Then, a section of PRM and geochemical reference materials (GRM) are run through the sensors (fig. 2) to monitor the data quality (tables 1, 3, and 4). A silica blank is run first to monitor the state of the pXRF's prolene dust film. When one or more elements besides silicon or LE (light elements) consistently report on the blank, the film is replaced. Next, the three GRM are analyzed in the same order every day. The KGS has developed 3D-printed pieces that match each PRM diameter to hold the silica blank and GRM. This allows the blank and GRM to be analyzed with the PRM, greatly increasing day-to-day efficiency as well as simplifying data reduction. The PRM are always analyzed in the same order (granite, dolomite, slate) and are marked to ensure they are always placed in the same orientation. Therefore, any variations in the PRM data are not due to a change in the analysis point location or PRM orientation (e.g., rotation of the PRM). All analysis points are taken within the middle 10 cm of the PRM, but the reported analysis point values (e.g., GR9-35B analysis point 29) are derived from their distance (in centimeters) from the start of the reference material section (i.e., GR9-35B analysis point 29 is 29 cm from the start of the section). The reported analysis point locations serve to demonstrate any changes in the selected locations from one project to the next (often as a result of procedural improvements), so that the behavior of each specific analysis point location on a PRM can be appropriately characterized over time across multiple projects.

Next, core is loaded onto the MSCL in sections up to 155 cm in length, and analyses from each sensor are taken every 10 cm with the following count times: gamma density (30 sec), natural gamma (120 sec), magnetic susceptibility (10 sec), and pXRF (45 sec per beam). The starting depth, length of each section, and analysis point depths are notated in a section tracking sheet in Microsoft Excel. At this time, any point that is determined to pose an issue to certain sensors (e.g., cracks interfering with pXRF, density, *Vp*, *Vs*, or other results) is flagged in the spreadsheet for removal during data processing (see section 4 for details). At the end of the day, the GRM and PRM sections are run again to monitor drift and ensure the sensors continued to function properly throughout the day. If anomalous reference material values are reported for a day's work, the core will be reanalyzed if possible; otherwise the affected data are removed from the dataset.

3.1. Portable X-Ray Fluorescence Spectrometer (pXRF)

The Vanta M-Series pXRF is equipped with a rhodium anode and used on Geochem (3-beam) mode (Beam 1, 10 kV; Beam 2, 20 kV; and Beam 3, 50 kV) with a graphene detector window. Each analysis point is analyzed for 45 seconds per beam exposure. The 3-beam analysis resolves major elements (Mg, Al, Si, P, S, Cl, Fe, K, Ca, and Ti), minor elements (Sr, V, Cu, Ni, Cr, Mn, and Pb), trace elements (Ba, Ce, La, Nd, Y, Co, Zn, As, Zr, Mo, Nb, Ag, Cd, Sn, Sb, Hf, Th, U, W, and Bi), and an aggregated "light elements" (H to Na). Detection limits (LOD) for these elements on the Vanta can be found in table 2.

4. Data Reduction

After the entire core has been analyzed, the data are collated using Python (v3.12.7), the reference materials are evaluated for anomalous values, and points with known issues (e.g., cracks) are removed from the dataset. This is because core defects that may pose issues to one sensor (e.g., cracks on core surface for pXRF) will not interfere with the measurements of others (e.g., natural gamma). When data are removed, they are replaced with a data substitution code indicating the reason for removal. Table 5 lists the data substitution codes and their explanations. A selection of data was plotted using Strater 5® by Golden Software (fig. 1). All depths reported are initial core depths, and no depths shifts have been applied.

In Bechtold #1, four *Vp* measurements greater than 8,500 m/s were identified as clear outliers and removed from the dataset along with their corresponding P-wave amplitude and impedance values (see section 4.2.3. for details). These outliers and their depths are available in table 6. The summary tables of the GRM (table 1) and PRM (tables 3 and 4) results are presented here and with the Bechtold #1 dataset (1002887925_Bechtold_1_MSCL_Data_20260422.xlsx), but the full results are made available separately. For the full geochemical reference material results and calculations, see "1002887925_Bechtold_1_MSCL_GRMTable_20260422.xlsx". For the petrophysical results and calculations, see "1002887925_Bechtold_1_MSCL_PRMTable_20260422.xlsx".

4.1. Geochemical Data Quality Assessment

The averages, standard deviations, relative standard deviations (RSD), and percent differences are calculated for each element per GRM (table 1). OREAS 463, SCo-2, and STM-1 were selected as the GRM for this project because these three offer the best elemental coverage out of any possible GRM combination available in the KGS collection. However, silver, cadmium, mercury, and selenium are unmonitored on the pXRF using this combination. In addition, bismuth, antimony, and tungsten are barely above LOD (bismuth and antimony LODs are 2 ppm; tungsten LOD is 1 ppm) in OREAS 463 (bismuth, 2.93 ppm; antimony, 2.14 ppm; tungsten, 2.45 ppm). Therefore, silver, bismuth, cadmium, mercury, selenium, antimony, and tungsten values should be taken with caution.

Unfortunately, the pXRF aborted its measurement due to low counts on two GRM analyses (morning SCo-2 and evening STM-1). At the time Bechtold #1 was analyzed, the KGS could only run powdered GRM in sample cups covered with prolene film. Over time, the powder compacts and leaves more air between the pXRF and the GRM powder, resulting in counts lower than the pXRF's abort threshold. The schedule did not allow for Bechtold #1 to be reanalyzed, therefore the precision of the geochemical data presented here can only be verified by the OREAS 463 results. The low relative standard deviations for all detected elements on OREAS 463 demonstrates good precision (i.e., low variability) for said elements. However, concentrations of cobalt, potassium, nickel, rubidium, sulfur, and uranium were not detected on either OREAS 463 analysis, despite having expected values above LOD. As a result, their precision cannot be verified.

Overall, aluminum, barium, cerium, potassium, lanthanum, neodymium, phosphorous, praseodymium, and silicon are reporting lower than expected. Values for calcium, iron, magnesium, manganese, strontium, and yttrium are also slightly lower than expected but not as noticeably as the previously mentioned elements. Lead is slightly under-reported on OREAS 463 (95.1 ± 4.4 ppm average; 130 ± 5 ppm expected) but very close to expected for SCo-2 (22.5 ppm result; 20.08 ± 0.2652 ppm expected) and STM-1 (20.1 ppm result; 18 ± 1.8 ppm expected). This indicates lead may be under-reported for larger concentrations (>100 ppm) but not for smaller ones (approximately 20 ppm).

Arsenic is slightly over-reported for all three GRM. Titanium is slightly over-reported on OREAS 463 (12,058 ± 49.3 ppm average; 8,760 ± 1,630 ppm expected) but very close to expected for SCo-2 (3,074.9 ppm result; 3,388 ± 12 ppm expected) and STM-1 (837.4 ppm result; 839 ± 60 ppm expected). This indicates titanium may be over-reported for larger concentrations (>8,000 ppm) but not for smaller ones (800–3,500 ppm). Molybdenum is slightly over-reported on OREAS 463 (66.4 ± 2.2 ppm average; 57 ± 3.6 ppm expected) but significantly higher on STM-1 (19.7 ppm) than expected (5.3 ppm). However, this could be because the STM-1 known molybdenum concentration is near the LOD (1 ppm). The instrument often struggles to accurately quantify very small elemental concentrations, even if they are technically above LOD. Regardless, the OREAS 463 results indicate that molybdenum is likely slightly over-reported across the board. Copper is also notably higher than expected, especially for STM-1 (22 ppm), but this is also likely due to the proximity of the known concentration (4.6 ppm) to the detection limit (2 ppm). Therefore, copper concentrations nearing 2 ppm are likely to be more inflated. Similarly, the tin STM-1 results (28.9 ppm) are higher than expected (6.8 ppm), which is close to the tin LOD (2 ppm). However, the average reported tin concentration for OREAS 463 (78.0 ± 5.6 ppm) is also significantly higher than expected (25.6 ± 2.47 ppm). Therefore, all tin results are likely inflated, regardless of proximity to LOD.

In addition, the Bechtold #1 GRM results illustrate issues with cobalt, chromium, sulfur, thorium, titanium, uranium, vanadium, and zirconium. As mentioned previously, cobalt was not detected on OREAS 463, but it also was not detected on STM-1. Cobalt reported for SCo-2 (19.9 ppm) is nearly twice the expected value (10.8 ± 0.1378 ppm). Chromium was significantly over-reported on OREAS 463 (2,676 ± 62 ppm average; 460 ± 86 ppm expected) but under-reported on SCo-2 (45.5 ppm result; 68.29 ppm expected). Sulfur was not reported on OREAS 463 or STM-1 despite their expected values (624 ± 46 ppm and 43 ppm, respectively) being well above LOD (15 ppm). SCo-2 does not have a known concentration of sulfur. It is possible the instrument is severely under-detecting sulfur.

The OREAS 463 results show thorium slightly under-reports on higher values (245.1 ± 11.4 ppm average; 291 ± 10 ppm expected), but the SCo-2 (29.4 ppm result; 9 ± 0.09076 ppm expected) and STM-1 (55.3 ppm result; 31 ± 3 ppm expected) results demonstrate an over-detection on lower concentrations (approximately 60 ppm), especially those approaching the LOD (2 ppm). Similarly, vanadium is slightly under-detected at higher concentrations (OREAS 463 144.6 ± 3.3 ppm average; 327 ± 26 expected) but struggles to quantify concentrations near the 5 ppm LOD (STM-1 did not report a value, but the expected concentration is 8.7 ppm). However, vanadium is accurately detected in SCo-2 (121.8 ppm result; 117 ± 1.196 ppm expected). This indicates that vanadium is only under-reported in higher values (>300 ppm) and accurate around values of 100 ppm but may be less accurate with concentrations lower than that.

The reported concentrations of zirconium for SCo-2 (177.9 ppm result; 183 ± 1.502 ppm expected) and STM-1 (1,192.1 ppm result; 1,210 ± 120 ppm expected) are accurate. However, the OREAS 463 zirconium average (456.1 ± 3.1 ppm) is higher than expected (256 ± 25 ppm) despite its known concentration sitting between those of SCo-2 and STM-1. Due to the aborted GRM analyses, the cause of this discrepancy is uncertain. For uranium, the GRM results all differ despite their similar expected values (7.55 ± 0.368 ppm OREAS 463, 3.2 ± 0.0544 ppm SCo-2, 9.1 ± 0.1 ppm STM-1). Uranium is not reported at all on OREAS 463, SCo-2 (6.3 ppm) is slightly higher than expected, and STM-1 (7.6 ppm) is lower than expected. These results indicate probable issues with the precision of uranium measurements.

In conclusion, caution is advised when evaluating Ag, Bi, Cd, Co, Cr, Hg, K, Ni, Rb, S, Sb, Se, Th, U, V, W, and Zr concentrations in Bechtold #1. Aluminum, Ba, Ca, Ce, Fe, K, La, Mg, Mn, Nd, P, Pr, Si, Sr, and Y are likely under-reported, while As, Mo, Cu, and Sn are likely over-reported. Lead may be under-reported for larger concentrations (>100 ppm), but not for smaller ones (approximately 20 ppm). In contrast, titanium may be over-reported for larger concentrations (>8,000 ppm), but not for smaller ones (800–3,500 ppm). Finally, all concentrations near the limits of detection should be treated with caution.

4.2. Petrophysical Data Quality Assessment

4.2.1. Core Thickness

The core thickness values of the PRM are very consistent, as indicated by their low relative standard deviations (table 3). In the Bechtold #1 dataset, a core thickness of 8.257 cm occurs at a depth of 2,438.83 ft. This is about 0.5 cm less than surrounding measurements, but the point was not flagged as a poor location for the core thickness measurements. Variation of 0.5 cm in the true core diameter is not unreasonable; therefore the 8.257 cm measurement was not removed from the dataset. In addition, density, *Vp*, *Vs*, impedance, and magnetic susceptibility values at 2,438.83 ft are not anomalous. Core thickness measurements are used to calculate the values for density, *Vp*, *Vs*, impedance, and magnetic susceptibility (using loop sensor).

4.2.2. Density

The PRM density values show little variability, with RSD ranging from 0.87% to 2.52% (table 3). The average densities for granite (2.65–2.66 g/cc), dolomite (2.34–2.35 g/cc), and slate (2.78–2.79 g/cc) are all within the expected ranges of 2.50–2.81 g/cc, 2.28–2.90 g/cc, and 2.70–2.90 g/cc, respectively (Oldenburg et al., 2017). In the Bechtold #1 data, two density results — 2.4015 g/cc at 2,441.94 ft and 2.2286 g/cc at 2,447.11 ft — are slightly lower than the surrounding density measurements (approximately 2.7 g/cc and 2.55 g/cc, respectively). However, the point was not flagged as a poor location for density measurements, and the associated core thickness, *Vp*, *Vs*, and impedance values are not anomalous. Therefore, these density points were not removed from the dataset.

4.2.3. Vp, Vs, and Impedance

The RSD for *Vs* (table 3) are low (0.01–0.2%) for all PRM results except analysis point 97 of SL5-3 (8.2% RSD). This is because the evening measurement (2,749.343 m/s) is higher than the morning measurement (2,449.488 m/s). However, all other *Vs* measurements are consistent. In addition, the GR9-35B granite (3,046–3,100 m/s) and D7-20 (2,375–2,392 m/s) *Vs* averages are within the expected ranges for granite and (2,500–3,300 m/s) and dolomite (1,900–3,600 m/s; Oldenburg et al., 2017).

The *Vp* RSD are all quite low (table 3), although the D7-20 (2.9–3.7%) RSD are slightly higher than those of GR9-35B (0.1–0.2%) and SL5-3 (0.4–0.7%). The same is true for the D7-20 impedance RSD (5–6%) compared to GR9-35B (1%) and SL5-3 (2%). This is unsurprising because impedance is calculated using *Vp*. The D7-20 *Vp* measurements are above the expected range of 3,500–6,500 m/s (Oldenburg et al., 2017) except the morning measurement at analysis point 61 (6,400.763 m/s). However, the GR9-35B *Vp* averages (4,505–4,796 m/s) are within the expected range for granite (4,500–6,000 m/s; Oldenburg et al., 2017). The slate *Vp* results fall within the 5,000–7,000 m/s range observed on other KGS slate PRM. The high D7-20 *Vp* results are likely caused by the technician's failure to properly pick the wave arrival times, which is a common

issue with this sensor. The MSCL technician visually assesses the waveforms and manually selects both wave arrivals within approximately 30 seconds. In this case, it appears the technician properly picked the *Vp* wave arrivals for GR9-35B but not for D7-20. Lastly, four *Vp* outliers with values above 8,500 m/s were removed from the dataset (table 6) along with their corresponding impedance values.

4.2.4. Magnetic Susceptibility

The GR9-35B and SL5-31 magnetic susceptibility results are very consistent (table 3), as illustrated by the small RSD (0.00–2.84% and 0.08–0.38%, respectively). However, the D7-20 magnetic susceptibility RSD (from -47.14% to -68.09%) are much larger, suggesting that magnetic susceptibility may be less precise on similar lithologies (e.g., carbonates).

4.2.5. Gamma Ray (Natural Gamma)

The API values of the PRM are consistent, as demonstrated by their low relative standard deviations (table 4). GR9-35B and SL5-3 have very low percent differences for API as well, but D7-20 does not. The inflated D7-20 API values are due to their proximity to both GR9-35B and SL5-3. Their API values are much greater, so the detectors pick up decays from GR9-35B and SL5-3 and attribute them to D7-20. This is a known issue that the KGS has since addressed.

The spectral uranium, potassium, and thorium results were determined to be invalid and removed from the dataset. The large spectral uranium RSD and percent differences across all three PRM demonstrate a lack of precision and accuracy in the results (table 4). The spectral thorium and potassium PRM results are more acceptable, but the Bechtold #1 spectral thorium and potassium results do not track the pXRF's thorium and potassium results whatsoever. Given the low API of the core, it is unsurprising that the spectral thorium and potassium results are effectively just noise. Much longer count times are likely required to produce accurate spectral results on such a minimally radioactive core. The spectral uranium, potassium, and thorium results can be made available upon request but are not presented herein due to the data quality issues.

4.2.6. Spectrophotometry

The reflectance percentages of the PRM are consistent, indicated by their relatively low relative standard deviations (table 3). However, the final spectrophotometry data point of the day, SL5-3 analysis point 100, was not recorded. This is a common issue with the MSCL, but the cause is yet to be determined. The missing value was flagged with the ER data substitution code to indicate an instrumental malfunction occurred. Several Bechtold #1 spectrophotometry data points were correctly determined by the technician to be unsuitable and removed from the dataset (data substitution code TR). These points were taken on the orientation lines, which biased the spectrophotometry results.

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			Ag	Al	As	Ba	Bi	Ca	Cd	Ce	Co	Cr
OREAS 463	Observed	Average (ppm)	BDL	29229	36.1	638.0	70.8	10226	BDL	3069.8	BDL	2676.0
		SD	BDL	790	0.2	35.29877	N/A	335	BDL	30.4	BDL	62.0
		n	0	2	2	2	1	2	0	2	0	2
		RSD (%)	N/A	2.7	0.5	5.5	N/A	3.3	N/A	1.0	N/A	2.3
		Percent Difference	N/A	-46.6	15.4	-43.8	2317.1	-14.1	N/A	-53.1	N/A	481.7
	Expected	**Average (ppm)**	**N/A**	**54700**	**31.3**	**1135**	**2.93**	**11900**	**N/A**	**6540**	**13.5**	**460**
		SD	*N/A*	*1210*	*1.75*	*46*	*0.18*	*720*	*N/A*	*220*	*0.61*	*86*
SCo-2	Observed	Average (ppm)	BDL	52135	13.6	403.1	BDL	24182	5.4	38.5	19.9	45.5
		SD	BDL	N/A	N/A	N/A	BDL	N/A	N/A	N/A	N/A	N/A
		n	0	1	1	1	0	1	1	1	1	1
		RSD (%)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Percent Difference	N/A	-25.0	15.9	-30.5	N/A	-14.1	N/A	-29.4	83.8	-33.4
	Expected	**Average (ppm)**	**N/A**	**69492**	**11.75**	**580**	**N/A**	**28159**	**N/A**	**54.47**	**10.8**	**68.29**
		SD	*N/A*	*219*	*0.2949*	*3.336*	*N/A*	*100*	*N/A*	*0.4452*	*0.1378*	*1.21*
STM-1	Observed	Average (ppm)	BDL	32200	6.9	257.7	BDL	6035	9.8	86.9	29.2	44.1
		SD	BDL	N/A	N/A	N/A	BDL	N/A	N/A	N/A	N/A	N/A
		n	0	1	1	1	0	1	1	1	1	1
		RSD (%)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Percent Difference	N/A	-66.9	50.0	-54.0	N/A	-22.5	N/A	-66.6	N/A	N/A
	Expected	**Average (ppm)**	**BDL**	**97384**	**4.6**	**560**	**BDL**	**7790**	**BDL**	**260**	**BDL**	**BDL**
		SD	*BDL*	*1217*	*N/A*	*60*	*BDL*	*429*	*BDL*	*18*	*BDL*	*BDL*

Table 1. Comparison of standards run as unknown during MSCL analysis (observed) to their reported values (expected). SD is standard deviation. RSD is relative standard deviation. BDL is below detection limit. All values are in parts per million. OREAS 463 expected values are from OREAS (Ore Research & Exploration Pty Ltd., 2025), SCo-2 from USGS (2022), and STM-1 from Smith (1995).

			Cu	Fe	Hg	K	La	Mg	Mn	Mo	Nb	Nd
OREAS 463	Observed	Average (ppm)	89.6	281086	BDL	BDL	3493.2	8926	673.9	66.4	1401.9	2363.1
		SD	10.4	577	BDL	BDL	117.9	528	22.5	2.2	4.9	80.4
		n	2	2	0	0	2	2	2	2	2	2
		RSD (%)	11.6	0.2	N/A	N/A	3.4	5.9	3.3	3.3	0.3	3.4
		Percent Difference	37.8	-15.7	N/A	N/A	-26.8	-11.6	-39.8	16.4	-6.2	-34.6
	Expected	**Average (ppm)**	**65**	**333300**	**N/A**	**1090**	**4773**	**10100**	**1120**	**57**	**1495**	**3611**
		SD	*3.2*	*10790*	*N/A*	*90*	*277*	*690*	*80*	*3.6*	*73*	*108*
SCo-2	Observed	Average (ppm)	27.2	31837	BDL	16287.3	BDL	9119	359.9	1.0	11.2	BDL
		SD	N/A	N/A	BDL	N/A	BDL	N/A	N/A	N/A	N/A	BDL
		n	1	1	0	1	0	1	1	1	1	0
		RSD (%)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Percent Difference	15.5	-2.0	N/A	-20.1	N/A	-46.9	8.1	-14.2	-0.4	N/A
	Expected	**Average (ppm)**	**23.53**	**32475**	**N/A**	**20371.89**	**28.43**	**17187**	**333**	**1.2**	**11.25**	**BDL**
		SD	*0.4149*	*111*	*N/A*	*65*	*0.3583*	*135*	*4*	*0.0487*	*0.1699*	*BDL*
STM-1	Observed	Average (ppm)	22.0	32951	BDL	26063.2	84.4	BDL	1524.7	19.7	265.1	BDL
		SD	N/A	N/A	BDL	N/A	N/A	BDL	N/A	N/A	N/A	BDL
		n	1	1	0	1	1	0	1	1	1	0
		RSD (%)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Percent Difference	378.3	-9.7	N/A	-26.6	-43.7	N/A	-10.3	272.1	-1.8	N/A
	Expected	**Average (ppm)**	**4.6**	**36510**	**N/A**	**35530**	**150**	**BDL**	**1700**	**5.3**	**270**	**79**
		SD	*N/A*	*699*	*N/A*	*581*	*6*	*BDL*	*120*	*N/A*	*12*	*7*

Table 1 — continued

			Ni	P	Pb	Pr	Rb	S	Sb	Se	Si	Sn
OREAS 463	Observed	Average (ppm)	BDL	1114.8	95.1	623.7	BDL	BDL	67.4	BDL	90567	78.0
		SD	BDL	23.4	4.4	34.8	BDL	BDL	N/A	BDL	676	5.6
		n	0	2	2	2	0	0	1	0	2	2
		RSD (%)	N/A	2.1	4.7	5.6	N/A	N/A	N/A	N/A	0.7	7.2
		Percent Difference	N/A	-81.1	-26.9	-36.7	N/A	N/A	3047.2	N/A	-29.5	204.6
	Expected	**Average (ppm)**	**76**	**5900**	**130**	**986**	**6.11**	**624**	**2.14**	**N/A**	**128500**	**25.6**
		SD	*4.4*	*540*	*5*	*36*	*0.58*	*46*	*0.22*	*N/A*	*3920*	*2.47*
SCo-2	Observed	Average (ppm)	26.0	BDL	22.5	BDL	101.9	5586.4	BDL	BDL	193044	BDL
		SD	N/A	BDL	N/A	BDL	N/A	N/A	BDL	BDL	N/A	BDL
		n	1	0	1	0	1	1	0	0	1	0
		RSD (%)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Percent Difference	-6.6	N/A	12.0	N/A	0.9	N/A	N/A	N/A	-33.2	N/A
	Expected	**Average (ppm)**	**27.8**	**789**	**20.08**	**BDL**	**101**	**N/A**	**BDL**	**N/A**	**289203**	**BDL**
		SD	*0.4372*	*5*	*0.2652*	*BDL*	*0.8617*	*N/A*	*BDL*	*N/A*	*397*	*BDL*
STM-1	Observed	Average (ppm)	BDL	BDL	20.1	BDL	110.7	BDL	BDL	BDL	134271	28.9
		SD	BDL	BDL	N/A	BDL	N/A	BDL	BDL	BDL	N/A	N/A
		n	0	0	1	0	1	0	0	0	1	1
		RSD (%)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Percent Difference	N/A	N/A	11.4	N/A	-6.2	N/A	N/A	N/A	-51.8	325.0
	Expected	**Average (ppm)**	**N/A**	**698**	**18**	**N/A**	**118**	**43**	**BDL**	**N/A**	**278592**	**6.8**
		SD	*N/A*	*44*	*1.8*	*N/A*	*6*	*N/A*	*BDL*	*N/A*	*2290*	*N/A*

Table 1 — continued

			Sr	Th	Ti	U	V	W	Y	Zn	Zr
OREAS 463	Observed	Average (ppm)	791.7	245.1	12058.0	BDL	144.6	BDL	160.5	358.0	456.1
		SD	5.4	11.4	49.3	BDL	3.3	BDL	0.6	4.6	3.1
		n	2	2	2	0	2	0	2	2	2
		RSD (%)	0.7	4.7	0.4	N/A	2.3	N/A	0.4	1.3	0.7
		Percent Difference	-15.2	-15.8	37.6	N/A	-55.8	N/A	-8.8	-8.5	78.2
	Expected	**Average (ppm)**	**934**	**291**	**8760**	**7.55**	**327**	**2.45**	**176**	**391**	**256**
		SD	*67*	*10*	*1630*	*0.368*	*26*	*0.38*	*10*	*30*	*25*
SCo-2	Observed	Average (ppm)	194.0	29.4	3074.9	6.3	121.8	BDL	22.3	104.0	177.9
		SD	N/A	N/A	N/A	N/A	N/A	BDL	N/A	N/A	N/A
		n	1	1	1	1	1	0	1	1	1
		RSD (%)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Percent Difference	-0.4	226.1	-9.2	97.5	4.1	N/A	-3.6	7.2	-2.8
	Expected	**Average (ppm)**	**194.7**	**9**	**3388**	**3.2**	**117**	**N/A**	**23.1**	**97**	**183**
		SD	*1.493*	*0.09076*	*12*	*0.0544*	*1.196*	*N/A*	*0.2586*	*0.856*	*1.502*
STM-1	Observed	Average (ppm)	696.3	55.3	837.4	7.6	BDL	BDL	38.5	245.5	1192.1
		SD	N/A	N/A	N/A	N/A	BDL	BDL	N/A	N/A	N/A
		n	1	1	1	1	0	0	1	1	1
		RSD (%)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Percent Difference	-0.5	78.4	-0.2	-16.2	N/A	N/A	-16.3	4.5	-1.5
	Expected	**Average (ppm)**	**700**	**31**	**839**	**9.1**	**8.7**	**N/A**	**46**	**235**	**1210**
		SD	*30*	*3*	*60*	*0.1*	*N/A*	*N/A*	*5*	*22*	*120*

Table 1 — continued

Element	Limit of Detection (ppm)
Ag	1
Al	125
As	1
Ba	10
Bi	2
Ca	20
Cd	1
Ce	30
Co	2
Cr	10
Cu	2
Fe	15
Hg	1
K	15
La	20
Mg	1,800
Mn	5
Mo	1
Nb	2
Nd	50
Ni	4
P	20
Pb	2
Pr	35
Rb	1
S	15
Sb	2
Se	1
Si	190
Sn	2
Sr	1
Th	2
Ti	20
U	1
V	5
W	1
Y	1
Zn	1
Zr	1

Table 2. Vanta M-Series limits of detection in parts per million using Geochem (3-beam) mode with a graphene detector window.

Name	Analysis Point		Core Thickness (cm)	P-Wave Amplitude	P-Wave Velocity (m/s)	S-Wave Amplitude	S-Wave Velocity (m/s)	Density (g/cc)	Magnetic Susceptibility (SI x 10^-5)	Impedance ($x10^3 kg/m^2 s$)	Spectrophotometer Reflectance (%): Red (595 - 700)	Spectrophotometer Reflectance (%): Green (515 - 595)	Spectrophotometer Reflectance (%): Blue (400 - 515)
GR9-35B	29	Average	8.356	0.098	4794	0.067	3100	2.65	6.48	12686	36.6	34.8	31.7
		SD (n=2)	0.003	0.023	6	0.003	1	0.03	0.18	157	1.0	1.0	0.9
		RSD (%)	0.034	24.004	0.1	3.999	0.04	1.11	2.84	1	2.6	2.8	2.8
	31	Average	8.357	0.107	4796	0.045	3046	2.65	6.68	12697	30.3	28.3	25.3
		SD (n=2)	0.002	0.026	3	0.006	3	0.02	0.00	101	0.1	0.1	0.2
		RSD (%)	0.025	24.707	0.1	12.345	0.1	0.87	0.00	1	0.3	0.4	0.9
	33	Average	8.359	0.090	4505	0.055	3063	2.66	6.68	11979	33.7	31.8	28.3
		SD (n=2)	0.001	0.002	9	0.002	23	0.03	0.08	102	0.6	0.6	0.5
		RSD (%)	0.017	1.892	0.2	3.892	0.7	1.06	1.27	1	1.8	1.8	1.9
D7-20	57	Average	8.386	0.080	7062	0.072	2378	2.35	-0.20	16580	82.3	76.2	66.6
		SD (n=2)	0.002	0.003	229	0.007	3	0.05	0.10	913	0.7	0.5	0.4
		RSD (%)	0.025	3.955	3.2	10.410	0.1	2.27	-49.50	6	0.8	0.7	0.5
	59	Average	8.385	0.083	8279	0.065	2392	2.34	-0.20	19419	82.5	76.7	67.0
		SD (n=2)	0.002	0.004	308	0.004	3	0.06	0.09	1212	0.9	0.8	0.6
		RSD (%)	0.025	4.782	3.7	6.025	0.1	2.52	-47.14	6	1.1	1.0	0.9
	61	Average	8.385	0.089	6533	0.051	2375	2.35	-0.14	15372	81.5	75.8	66.5
		SD (n=2)	0.000	0.011	187	0.002	6	0.05	0.09	762	0.8	0.7	0.5
		RSD (%)	0.000	12.813	2.9	4.742	0.2	2.10	-68.09	5	1.0	0.9	0.8
SL5-3	95	Average	8.367	0.151	6721	0.058	2446	2.79	49.90	18771	19.9	20.5	21.2
		SD (n=2)	0.003	0.001	28	0.007	0.2	0.06	0.14	329	0.8	0.8	0.7
		RSD (%)	0.034	0.794	0.4	12.213	0.01	2.17	0.28	2	3.9	3.7	3.5
	97	Average	8.367	0.168	6607	0.065	2599	2.78	50.16	18394	25.7	26.6	27.4
		SD (n=2)	0.003	0.010	46	0.017	212	0.06	0.04	288	1.0	1.0	1.1
		RSD (%)	0.034	6.017	0.7	26.844	8.2	2.26	0.08	2	3.8	3.9	3.9
	100	Average	8.366	0.157	6498	0.055	2465	2.78	49.67	18084	17.2	17.7	18.5
		SD (n=2)	0.003	0.008	30	0.000	2	0.06	0.19	333	ER	ER	ER
		RSD (%)	0.034	5.394	0.5	0.648	0.1	2.30	0.38	2	ER	ER	ER

Table 3. Comparison of results for petrophysical reference materials run during MSCL analysis. SD is standard deviation. RSD is relative standard deviation. GR9-35B is granite, D7-20 is dolomite, and SL5-3 is slate. Analysis point values are derived from their distance (in centimeters) from the start of the reference material section (see section 3 for details).

Name	Analysis Point		Gamma Ray (API)	Spectral K (wt%)	Spectral U (ppm)	Spectral Th (ppm)
GR9-35B	29	Average	162.4	4.2	17.3	21.9
		SD (n=2)	2.5	0.7	7.0	1.9
		RSD (%)	1.5	17.7	40.1	8.5
		Expected Value	169.0	4.6	15.1	21.9
		Percent Difference	-3.9	-9.7	14.7	0.1
	31	Average	166.5	6.6	-2.8	20.2
		SD (n=2)	2.8	1.5	19.3	5.4
		RSD (%)	1.7	23.4	-681.2	26.8
		Expected Value	169.0	4.6	15.1	21.9
		Percent Difference	-1.5	42.7	-118.7	-7.5
	33	Average	167.0	3.7	25.1	24.2
		SD (n=2)	1.9	0.3	2.2	0.2
		RSD (%)	1.1	8.3	8.9	0.7
		Expected Value	169.0	4.6	15.1	21.9
		Percent Difference	-1.2	-19.9	66.0	10.4
D7-20	57	Average	40.8	1.4	-6.3	1.6
		SD (n=2)	0.9	0.3	4.4	0.7
		RSD (%)	2.3	24.0	-70.5	42.5
		Expected Value	28.8	0.1	0.4	0.3
		Percent Difference	41.7	1316.0	-1674.1	436.2
	59	Average	37.7	-0.9	18.9	6.5
		SD (n=2)	0.0	0.1	0.8	0.3
		RSD (%)	0.1	-5.3	4.2	4.2
		Expected Value	28.8	0.1	0.4	0.3
		Percent Difference	31.0	-1040.5	4630.8	2066.7
	61	Average	36.6	0.2	3.3	2.0
		SD (n=2)	0.1	0.6	12.0	4.4
		RSD (%)	0.1	372.0	365.6	215.9
		Expected Value	28.8	0.1	0.4	0.3
		Percent Difference	27.1	68.2	723.0	572.5
SL5-3	95	Average	105.0	3.8	8.9	19.1
		SD (n=2)	2.2	1.0	10.2	1.2
		RSD (%)	2.1	25.4	115.4	6.5
		Expected Value	104.4	4.2	4.2	17.6
		Percent Difference	0.6	-9.4	111.0	8.7
	97	Average	102.6	4.2	3.0	17.1
		SD (n=2)	3.2	0.3	7.4	3.1
		RSD (%)	3.1	8.0	244.9	18.2
		Expected Value	104.4	4.2	4.2	17.6
		Percent Difference	-1.7	0.5	-28.4	-2.8
	100	Average	102.8	3.0	10.7	15.9
		SD (n=2)	3.3	0.4	7.9	2.9
		RSD (%)	3.2	11.8	74.4	18.4
		Expected Value	104.4	4.2	4.2	17.6
		Percent Difference	-1.5	-28.9	154.3	-9.6

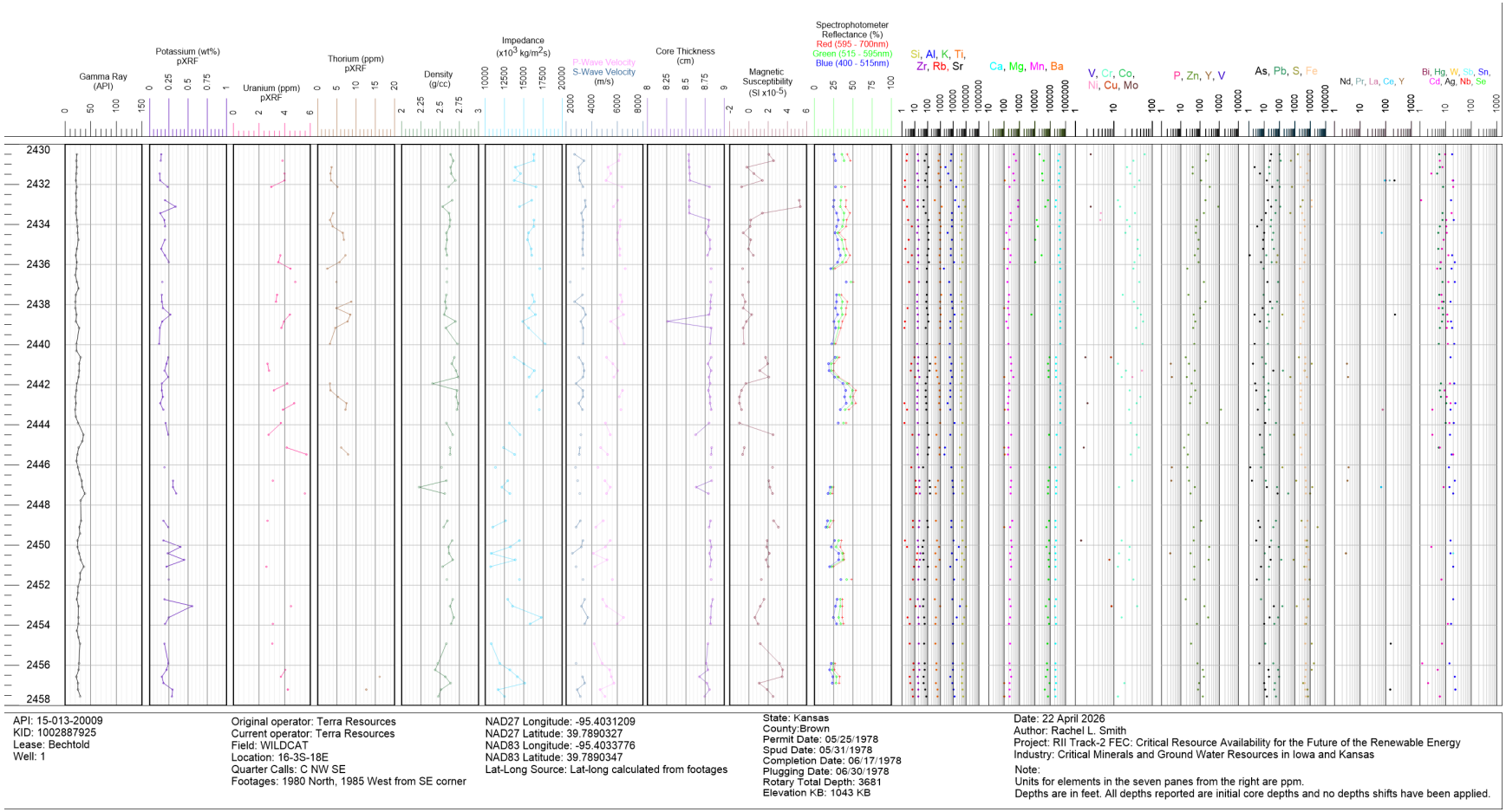
Table 4. Comparison of petrophysical reference materials run as unknown during MSCL analysis (observed) to their reported API and spectral potassium, uranium, and thorium values (expected). SD is standard deviation. RSD is relative standard deviation. Expected values are provided by Geotek Ltd. and are unique to each reference material. GR9-35B is granite, D7-20 is dolomite, and SL5-3 is slate. Analysis point values are derived from their distance (in centimeters) from the start of the reference material section (see section 3 for details).

Code	Explanation
ABR	pXRF aborted measurement because the total counts detected on Beam 1 were below the abort threshold (e.g., 50,000 counts).
AMP	Amplitude of 0 reported, indicating invalid *Vp* or *Vs* results. Because impedance is calculated from *Vp* and density, a *Vp* amplitude of 0 will invalidate its corresponding impedance.
BDL	Below detection limit of the pXRF.
CER	Spectrophotometry calibration cap was not removed, resulting in invalid reflectance values greater than or equal to 100%.
EE	Edge effect. This point is within 6 cm of a section edge, which results in an underrepresented natural gamma response (API, spectral K, U, and Th).
ER	Error. Instrument malfunction led to these data not being collected or reported.
HNG	This point was determined by the lab technician to only be appropriate for the natural gamma sensor and horizontal sensors (e.g., core thickness, density, *Vp*, *Vs*, impedance, loop magnetic susceptibility). Typically, this is due to an imperfection in the core that would not allow for good coupling between the vertical sensors and the core surface.
NA	Not analyzed.
NG	This point was determined by the lab technician to only be appropriate for the natural gamma sensor (API, spectral K, U, and Th). Typically, this is due to cracks or other imperfections in the core.
NV	Not verified. Data from reference materials were either not collected or inconclusive.
OUT	Outlier identified during data processing.
TR	Technician removal. Point determined to be an outlier in the lab by the technician during analysis.
VNG	This point was determined by the lab technician to only be appropriate for the natural gamma sensor and vertical arm sensors (e.g., pXRF, point magnetic susceptibility, spectrophotometer). Typically, this is due to a side crack or void in the core.

Table 5. Data substitution codes and their explanations for data removal.

Outliers Removed from Dataset				
Depth	Date	P-Wave Amplitude	P-Wave Velocity	Impedance
ft	MM/DD/YYYY		m/s	$x10^3 kg/m^2 s$
2433.44	12/10/2024	0.0831	9845.621	25773.57
2436.86	12/10/2024	0.0122	8736.634	22579.25
2441.94	12/10/2024	0.0781	9805.339	23547.76
2442.93	12/10/2024	0.0663	11172.37	30528.38

Table 6. *Vp* and corresponding impedance and amplitude outliers removed from the Bechtold #1 dataset. See section 4.2.3. for more information.



API: 15-013-20009
KID: 1002887925
Lease: Bechtold
Well: 1

Original operator: Terra Resources
Current operator: Terra Resources
Field: WILDCAT
Location: 16-3S-18E
Quarter Calls: C NW SE
Footages: 1980 North, 1985 West from SE corner

NAD27 Longitude: -95.4031209
NAD27 Latitude: 39.7890327
NAD83 Longitude: -95.4033776
NAD83 Latitude: 39.7890347
Lat-Long Source: Lat-long calculated from footages

State: Kansas
County:Brown
Permit Date: 05/25/1978
Spud Date: 05/31/1978
Completion Date: 06/17/1978
Plugging Date: 06/30/1978
Rotary Total Depth: 3681
Elevation KB: 1043 KB

Date: 22 April 2026
Author: Rachel L. Smith
Project: RII Track-2 FEC: Critical Resource Availability for the Future of the Renewable Energy Industry: Critical Minerals and Ground Water Resources in Iowa and Kansas

Note:
Units for elements in the seven panes from the right are ppm.
Depths are in feet. All depths reported are initial core depths and no depths shifts have been applied.

Figure 1. Bechtold #1 MSCL data plotted with depth using Strater 5® by Golden Software. See “1002887925_Bechtold_1_MSCL _Figure1_20260422.pdf” for a higher-resolution figure.

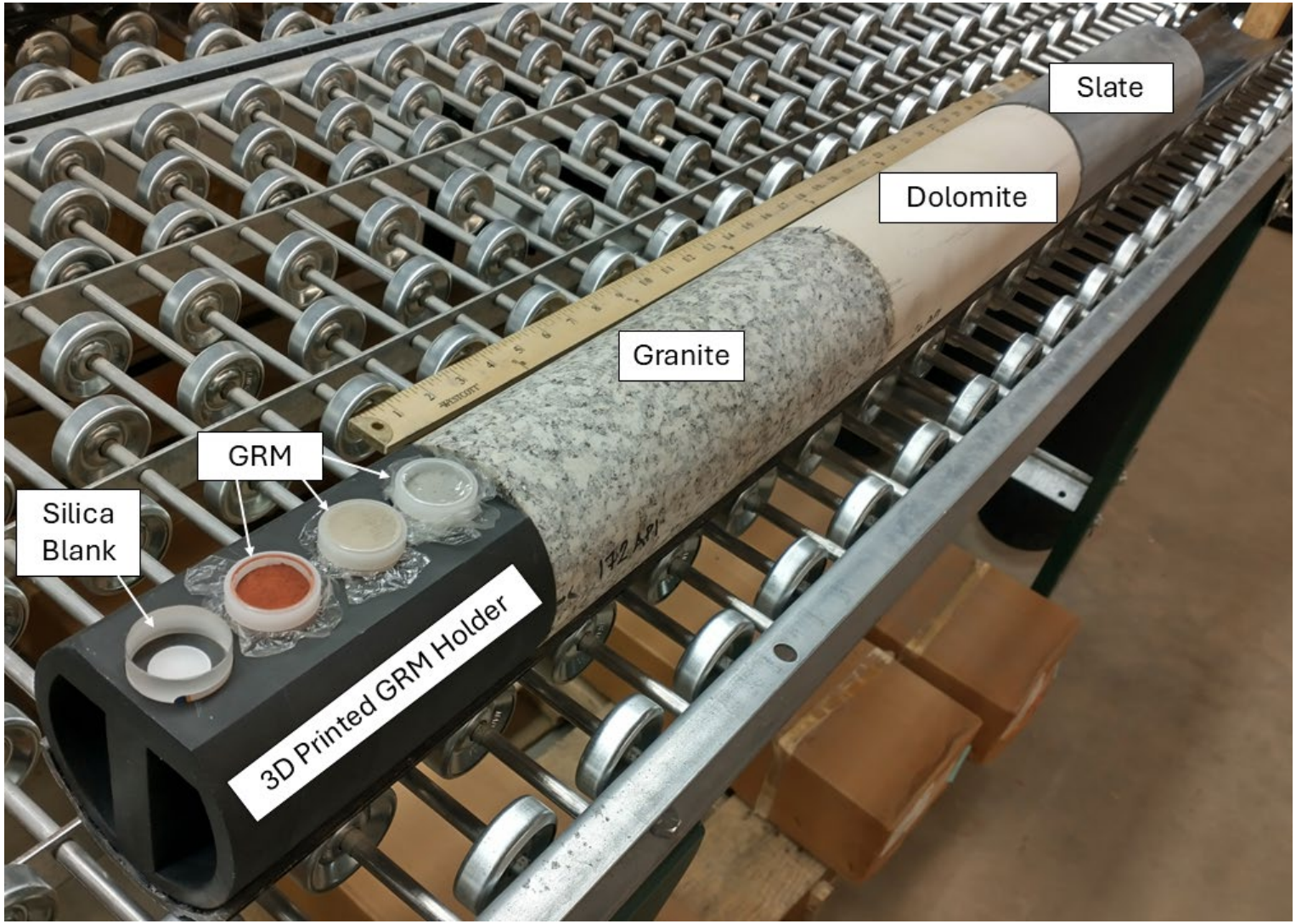


Figure 2. The reference material section setup for 4-in. diameter core. Geochemical reference materials (GRM) are in front, beginning with a silica blank. The petrophysical reference materials are 30-cm-long sections of granite, dolomite, and slate, which follow the GRM.