Geological Analysis of the Fluctuation of Radiation within the Tom Mays Mine, El Paso, Texas

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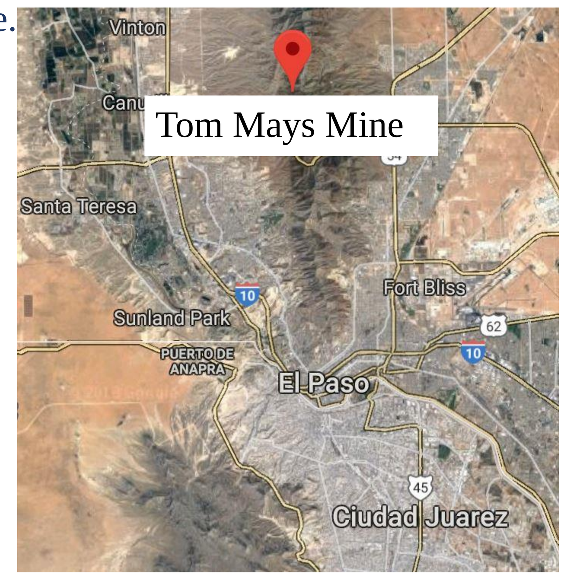
Introduction

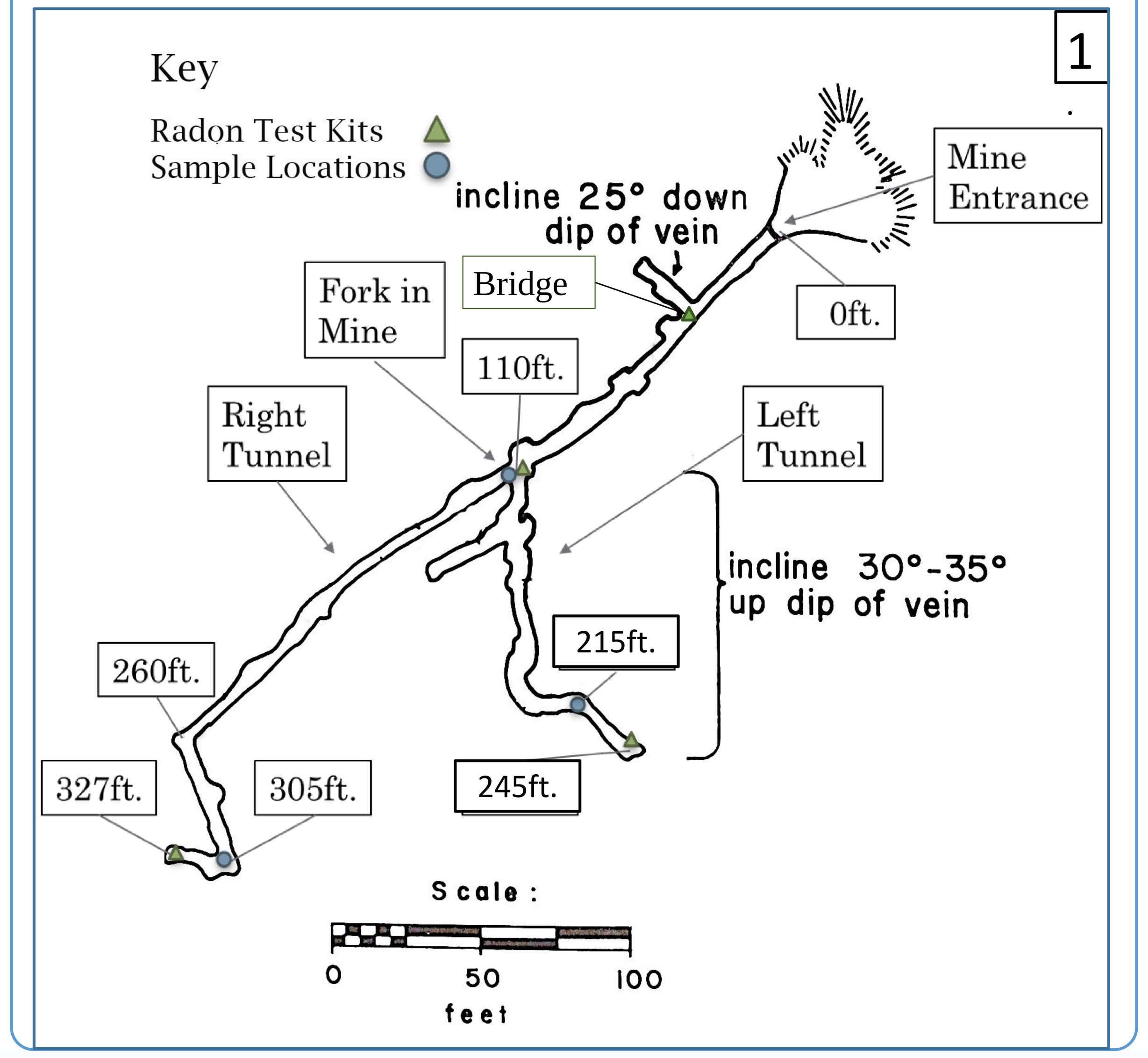
Tom Mays Mine is located in the Franklin Mountains State Park near El Paso, Texas. The mine follows a substantial copper vein that crosses through a fault and the contact between the Red Bluff Granite (1.2 Ga) and a basalt dike (1.2 Ga, but after the Red Bluff Granite). The fault is found to trend N60°E and dips 35°NW and follows the trend of the mine shaft and the basalt dike, which seems to have the same trend and dip. The origin of the copper vein is conjectural, though past studies suggest that the copper vein developed from magmatic activity that formed a nearby felsite sill (Lovejoy, 1975), with mineralization occurring from hydrothermal solutions or heating of connate waters from intrusives (Goodell, 1976). This places the age of the copper vein to around 28 Ma. Nonetheless, the copper vein is thought to be secondary mineralization, with the quartz veins (around 1 Ga) being primary mineralization and part of a Precambrian hydrothermal vent. The mine consists of a 110ft tunnel that then splits into two separate tunnels, the tunnel on the right follows the copper vein and the trend of the fault, while the tunnel on the left follows the vein and the strike of the fault at an incline. Upon entering the mine, radiation could be detected on a Gamma Scout at levels higher than background and noticeably varied throughout the mine.



The objectives of this project are to determine the cause of fluctuation in radiation throughout the mine, how much the radiation fluctuates, and to evaluate if the mine is safe for tours. (In order to progress further research on the mine a State Park Scientific Study Permit was acquired.)

Methods

Several methods were used to determine the cause of fluctuation in radiation throughout the mine. First of all, using an old map created by Dr. Philip Goodell (1976), the general layout of the mine was confirmed and further mapped, using a compass and measuring tape. Later on, when other tests and samples are taken, their locations were indicated on the map as shown in Figure 1. The map will also be used to correlate with the radiological surveys conducted.



Methods Cont.

Radiological Surveys

Using a certified Ludlum Survey Meter 3 Model 44-9 with a pancake probe, radiological surveys were conducted within the mine. Radiation was measured every 5 feet within the mine starting at the entrance and the average was recorded in cpm (counts per minute). Leaving the slim plastic lid on the probe at certain areas in the mine provided a bit of shielding, demonstrating that more than half of the radiation detected was not alpha radiation. The results are shown in Figure 2-4.

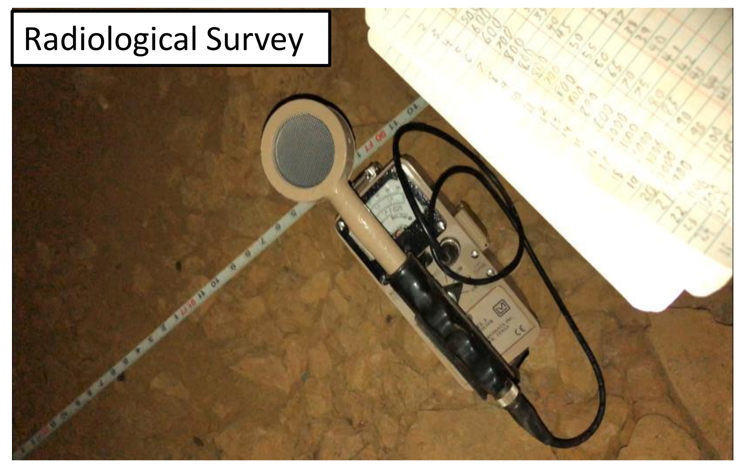
Radon Test Kits

After conducting a few surveys, it was observed that there were days where the levels of radiation varied substantially from the other survey days, from 100-500cpm. This prompted the idea that Radon gas could be a factor in the fluctuation in radiation, especially when the atmospheric pressure changes. Which is why Pro-Lab radon test kits were prepared and placed at various parts of the mine. After the test kits where left in the mine for four days, they would be sent to a testing facility designated by the company Pro-Lab, where the amount of radon would be determined in pCi/L (picocuries per liter). The results are shown in Figure 4.

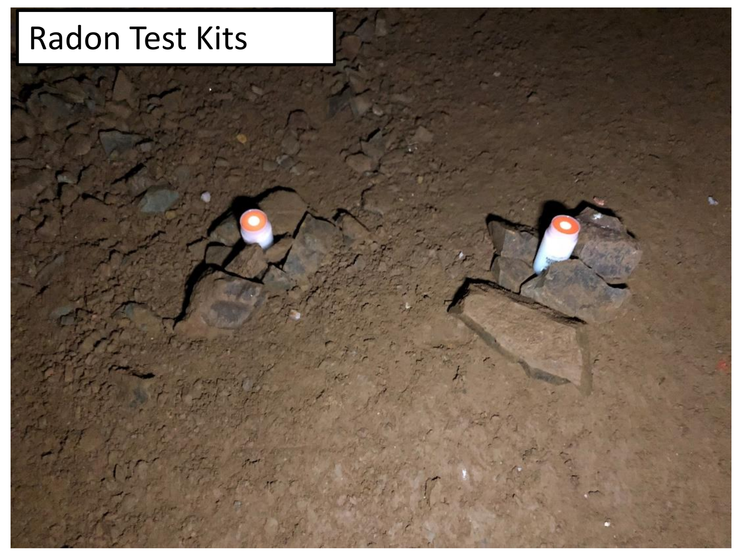
Rock Samples

Rock samples were taken to pinpoint the exact cause in the fluctuation of radiation, and to determine the composition in the differing rocks within the mine. At various areas of the mine, samples of the Red Bluff Granite, basalt dike, and quartz vein were collected from the mine's walls. The samples would then be sent over to the WSU GeoAnalytical Laboratory to undergo ICP-MS (inductively coupled plasma mass spectrometry) analysis for trace elements.

Radiological Survey

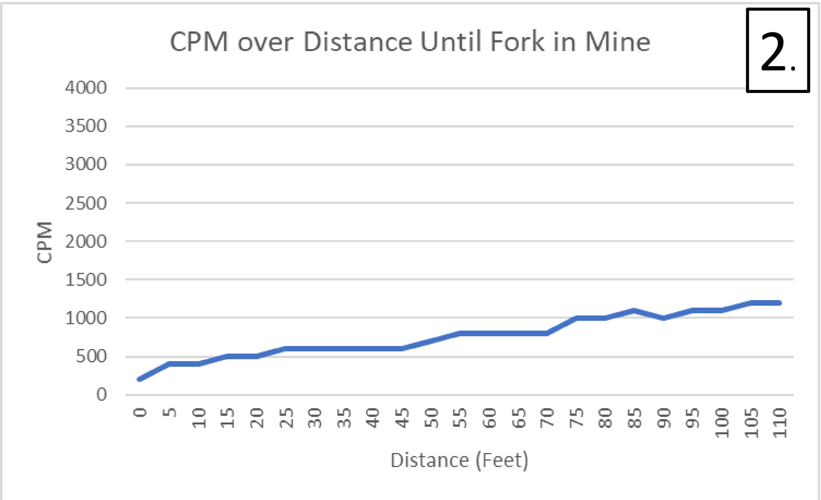


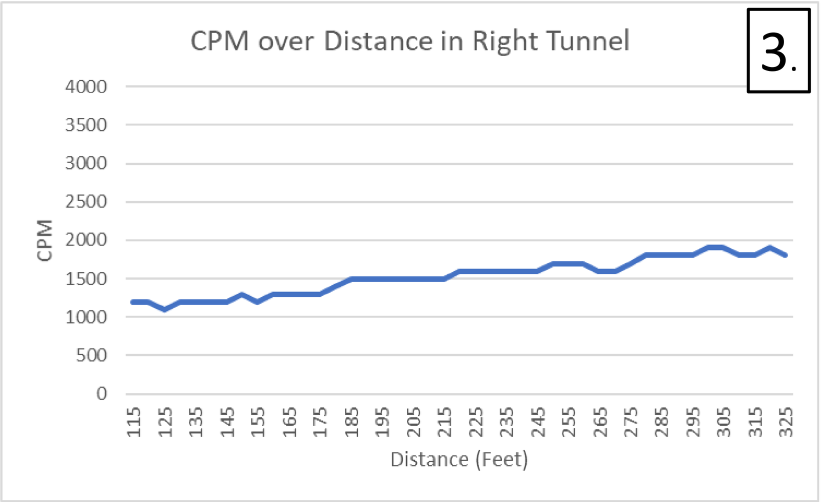
Radon Test Kits

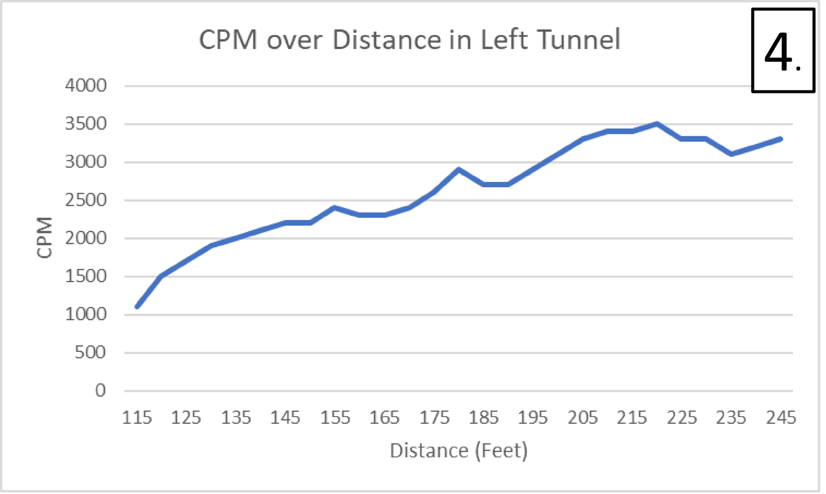


Results

Radiological Surveys







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Radon Test Kit Data

Location	Radon Gas (pCi/L)
Bridge	287.9
Fork in Mine	2012.9
End of Right Tunnel	376.7
End of Left Tunnel	1838.7

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ICP-MS Data of Rock Samples

Sample ID	La ppm	Ce ppm	Pr ppm	Nd ppm	Sm ppm	Eu ppm	Gd ppm	Tb ppm	Dy ppm	Ho ppm	Er ppm	Tm ppm	Yb ppm	Lu ppm
Red Bluff Granite FM	74.27	149.35	16.87	57.47	12.19	1.18	11.45	2.36	15.82	3.33	10.41	1.82	12.65	1.91
Basalt Dike FM	54.03	105.69	12.11	46.51	12.20	1.90	12.41	2.26	14.76	3.30	11.02	1.96	14.48	2.52
Quartz Vein FM	0.37	0.77	0.09	0.35	0.23	0.04	0.71	0.24	2.08	0.54	2.11	0.43	3.31	0.54
Red Bluff Granite RT	6.24	12.50	1.42	5.46	2.96	0.67	6.89	2.01	16.14	3.77	12.81	2.31	16.17	2.57
Basalt Dike RT	132.15	277.13	29.21	107.34	21.31	3.07	16.88	2.71	16.51	3.54	10.78	1.69	10.59	1.65
Quartz Vein RT	5.98	11.10	1.18	4.25	0.78	0.10	0.58	0.10	0.58	0.12	0.36	0.06	0.42	0.06
Red Bluff Granite LT	3.14	6.60	0.66	2.41	1.04	0.19	2.22	0.73	6.43	1.68	6.34	1.28	9.89	1.61
Basalt Dike LT	28.62	59.63	7.38	31.08	7.81	1.54	8.95	1.61	10.04	2.12	6.42	1.02	7.08	1.17
Quartz Vein LT	816.93	1605.14	163.41	570.47	90.26	10.38	43.53	4.20	14.46	1.84	4.15	0.66	4.70	0.80

Sample ID	Ba ppm	Th ppm	Nb ppm	Y ppm	Hf ppm	Ta ppm	U ppm	Pb ppm	Rb ppm	Cs ppm	Sr ppm	Sc ppm	Zr ppm
Red Bluff Granite FM	137	48.61	75.56	85.87	9.17	13.89	18.13	5.33	362.5	1.16	12	1.1	141
Basalt Dike FM	265	20.19	168.96	120.06	16.94	9.48	6.99	6.86	1080.6	3.43	205	11.5	743
Quartz Vein FM	144	0.42	1.05	23.49	0.04	0.06	0.58	1.53	1.9	0.14	6	0.5	1
Red Bluff Granite RT	224	61.64	87.29	110.69	10.70	11.55	12.16	3.55	304.9	1.55	12	1.8	186
Basalt Dike RT	279	19.38	157.06	127.48	15.56	8.79	5.88	9.14	610.8	4.57	81	9.5	693
Quartz Vein RT	5	0.27	1.63	6.75	0.05	0.32	0.19	1.05	2.3	0.08	8	0.2	2
Red Bluff Granite LT	84	11.74	86.98	53.09	11.22	13.08	7.28	3.52	326.1	1.22	9	1.4	188
Basalt Dike LT	749	10.25	140.72	71.38	15.15	8.24	6.18	5.48	862.5	2.30	41	10.6	676
Quartz Vein LT	98	10.10	8.35	70.09	0.92	0.59	2.30	14.76	66.3	0.49	24	2.2	40

Key: FM = Fork in Mine, RT = Right Tunnel, LT = Left Tunnel

The radiological surveys revealed that the amount of radiation fluctuates differently depending on the area of the mine. Data from the mine entrance through to the end of the right tunnel in Figures 2-3 shows that the radiation increases more exponentially. While the data gathered from the left tunnel in Figure 4, shows that the radiation sharply increases and does not keep close to a somewhat, steady rate compared to the data gathered from the mine entrance to the end of the right tunnel. Furthermore, the radiation in the left tunnel peaks at an average of 3500cpm with spikes up at around 4000cpm which is much higher than that of the right tunnel which peaks at an average of 1900cpm.

The results of the radon test kits in Figure 5, revealed that radon gas was present in the mine at high levels. The highest level recorded was at 2012.9pCi/L at the fork, while the lowest level was 287.9pCi/L at the bridge in the middle of the fork and the entrance of the mine. The test kits gives a good idea of the levels of radiation, but may be inaccurate since they are to be used in buildings.

The data from the ICP-MS analysis in Figure 6 showed that the rock samples of Red Bluff Granite, the basalt dike, and the quartz vein, varied in the amount of most trace elements, even when compared to samples of the same material from a different area of the mine. Focusing more on the content of uranium and thorium, it is found that the samples from the mine don't contain very much, as to have too much of an influence on radiation levels throughout the mine. Although it is noted that the Red Bluff Granite sample near the end of the right tunnel contains the most thorium at 61.64ppm with 12.16ppm of uranium, while the Red Bluff Granite sample from the fork in the mine contains the most uranium at 18.13ppm with 48.61ppm of thorium. The Red Bluff Granite sample from the left tunnel is found to contain the lowest amounts of both thorium and uranium, at amounts around or below 10ppm.

Conclusions

Based on the results, how the samples are Precambrian material, and due to the mine residing in a fault zone, it is suggested that the fluctuation of radiation throughout the mine is caused mostly by radon gas. This is due to the fact that the amount of uranium and thorium in all the rock samples are not at amounts that would effectively change the level of radiation throughout the mine, nonetheless, causes changes remotely close to 1000cpm. Instead, the alpha, beta, and gamma radiation emitted throughout the mine is mostly caused by the decay of radon gas. Since after radon decays quickly into polonium, the polonium then instantaneously decays into isotopes of lead and actinium which decays instantaneously further down the uranium decay chain. And, in turn, emits alpha, beta, and even more gamma radiation. This explains why high levels of gamma and beta radiation can be observed and why it may fluctuates on days of different atmospheric pressure. It can also show that the amount of radiation can just fluctuate, regardless of atmospheric pressure, depending on how much radon gas is present in the mine and over time as the half-life for radon is only 3.8 days. And why the levels of thorium are higher than uranium in every rock sample throughout the mine, indicating that the original uranium content has decayed quite a bit, due to the age of the rock. Also, due to the mine being in a fault zone, the radon gas generated from rocks deeper below the mine would rise through the fractures caused by faulting into the mine, which would act as a "reservoir" for the gas. Therefore, high amounts of radon could be observed by the radon test kits, which show that the end of the left tunnel had 1838.7pCi/L of radon gas, which is higher than the right tunnel that only had 376.7pCi/L of radon gas. And explains how the left tunnel has the highest levels of radiation at 3500cpm with spikes up to 4000cpm, while the amount of thorium and uranium in its rock samples was much less compared to the samples from the other areas of the mine. Though unlikely, it could be possible that the levels of radiation may be in part due to the amount of radium within the Red Bluff Granite. Moving on, it is determined that the mine is safe for tours as the amount of time exposed to the levels of radiation and radon gas is considered minimal.

Future Work

- Take better rock samples and take samples of the dirt in the mine
- Use a digital geiger counter with proper levels of shielding and gather data over longer periods of time throughout the mine
- Use a better method to determine amount of radon gas in the mine and see if it changes during time
- Conduct an XRD analysis on rock and dirt samples to determine precise isotopes of elements within
- Determine if other trace elements have an effect on emitted radiation

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