

Tracking Radon Gas Above Deeply Buried Uranium Ore

Mary Devine

K. Hattori and J. Cornett

Millennium Deposit – Athabasca Basin, Saskatchewan

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Geologic Setting



Juhojuntti et al., 2012



- The Athabasca Basin, SK hosts the world's highest grade uranium deposits.
- Unconformity-associated uranium deposits such as these account for 33% of worldwide uranium production. (Cuney & Kyser, 2008)



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Geologic Setting



Juhojuntti et al., 2012



- Many of these U deposits occur below thick sandstones and overburden up to 900 m deep which poses a challenge during exploration.
- The unconformity is at shallow depths in the eastern part of the Athabasca Basin, and reaches depths of <1.5 km towards the centre of the basin.



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Initial Research Objectives

(222)

Rn

86 RADON

This study examines the behavior of radon (Rn) dissolved in groundwater at Cameco's Millennium deposit.

- Determine if Rn concentrations above the Millennium deposit are anomalous.
- Define a footprint area of anomalous Rn.
- Find the most effective sampling and analyzing techniques.
- Determine how/if physical and chemical parameters of groundwater correlate with Rn activity, including:
 - ❖ Conductivity
 - ❖ pH
 - ❖ Cl⁻
 - ❖ He
 - ❖ ³H



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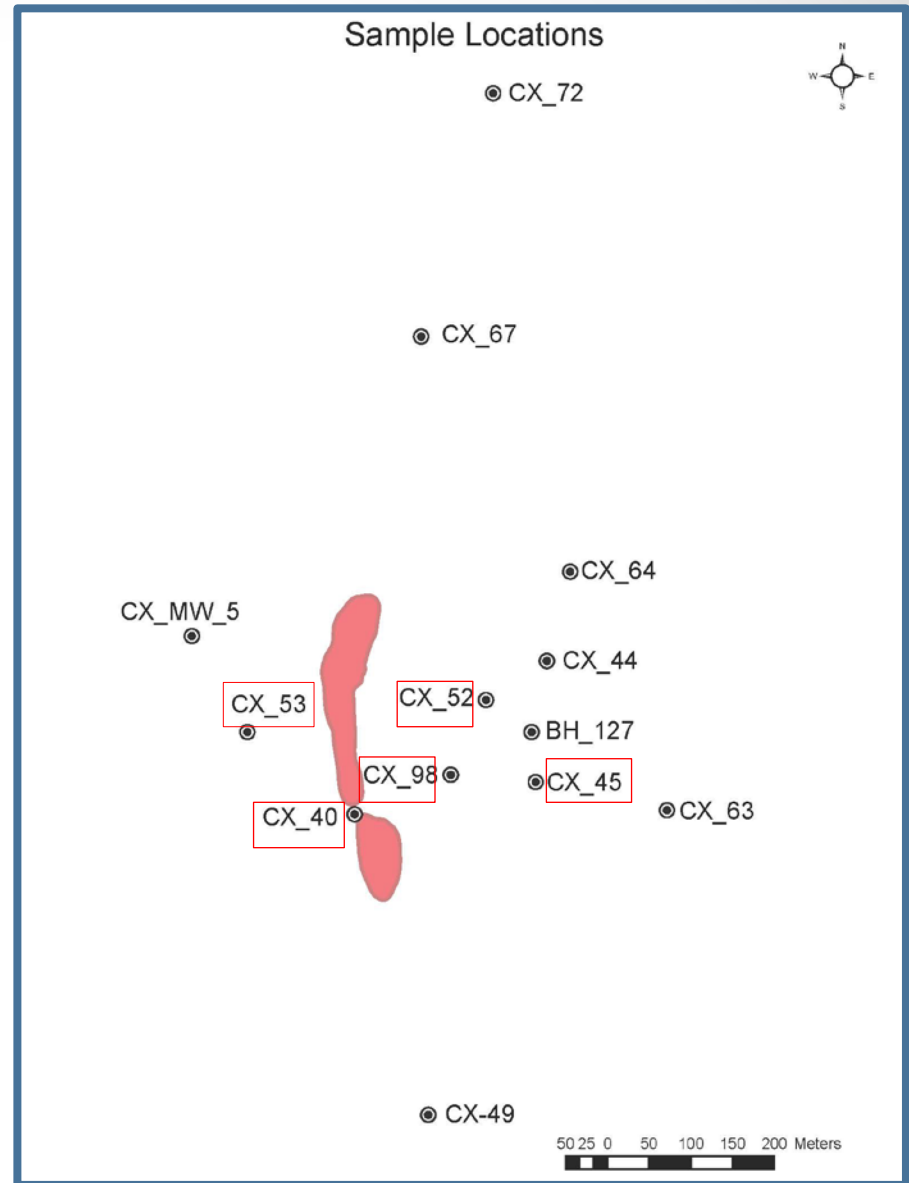
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Sampling Area

Millennium Deposit

Sample locations were chosen based on proximity to the surficial expression of mineralization and accessibility.

Intersects mineralization at depth



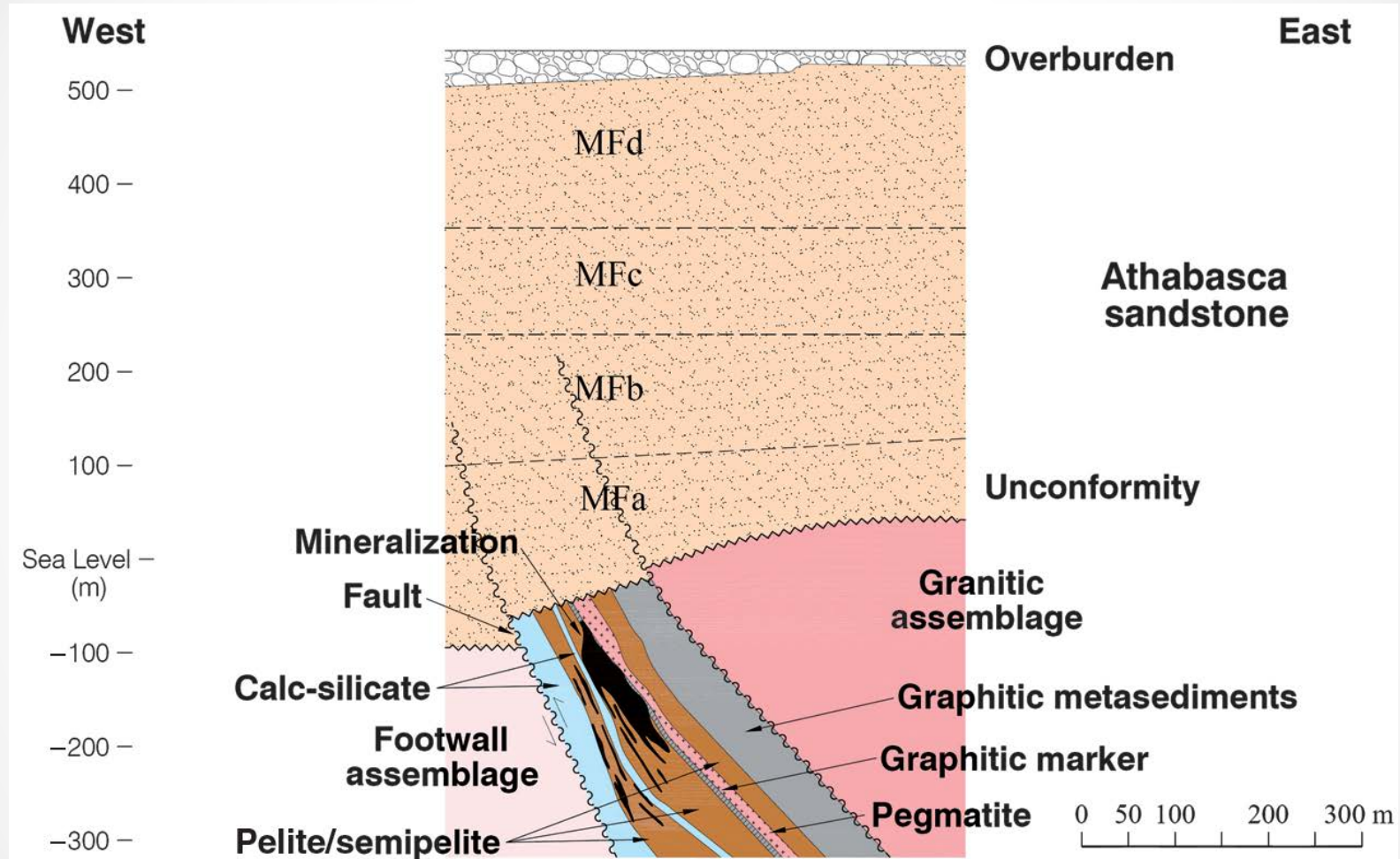
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Millennium Deposit

68.2 M lbs (indicated resource) and 22.3 M lbs (inferred resource) U_3O_8



Juhojuntti et al., 2012



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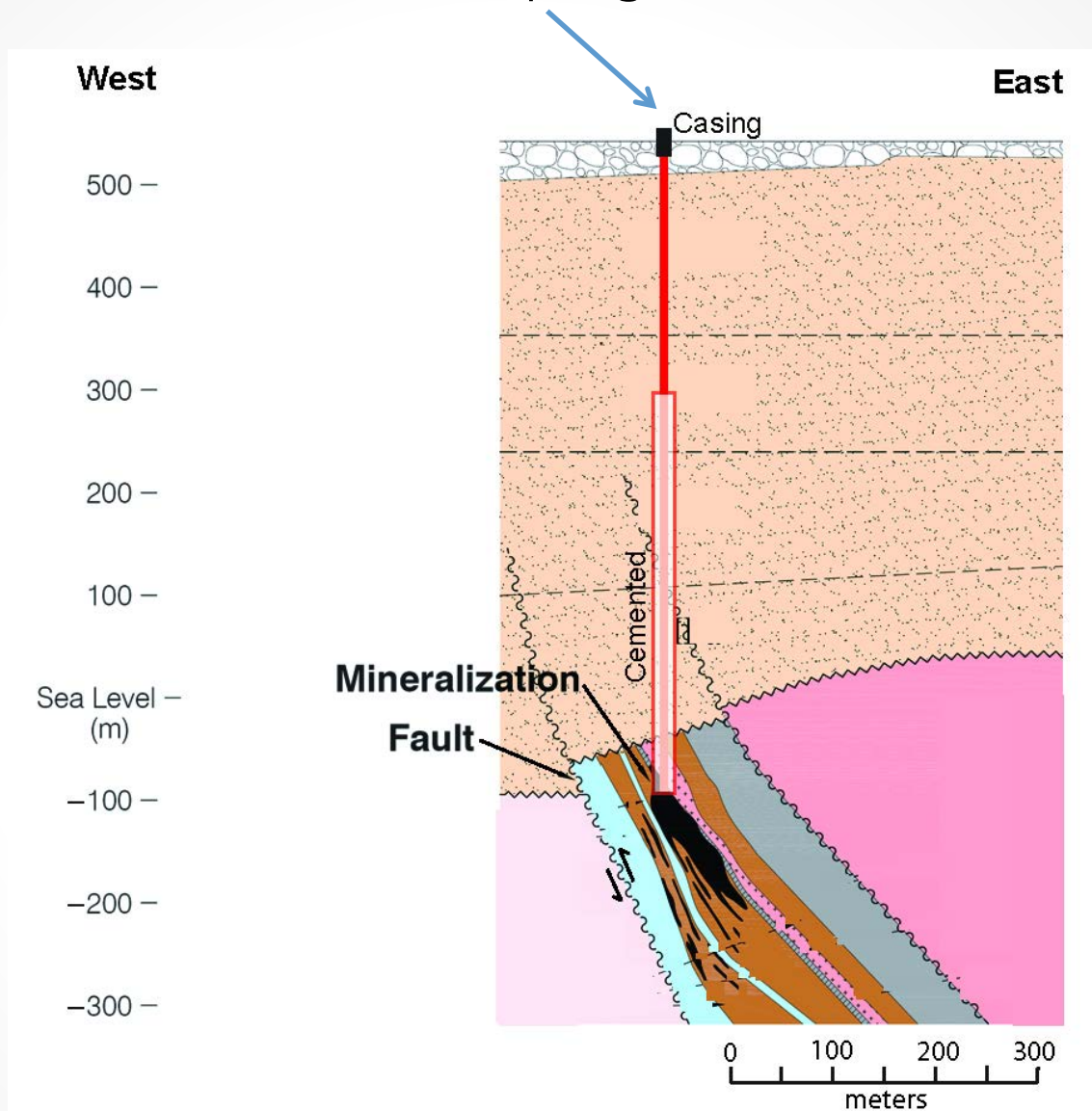


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Groundwater sampling location



1. Extraction Method

Lefebvre et al., 2013

- Water is poured directly from bailer to 500 mL transparent glass bottles
- Analyzed with one week of sampling
- Extraction and analysis occur in the lab at UQAM using the Extraction Method (EM)



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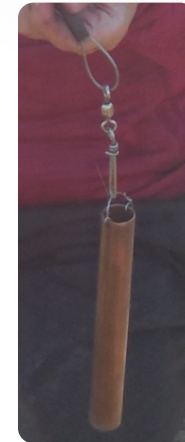


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2. Polyethylene Method:

Leaney & Herczeg (2006)

- Water is poured directly from bailer into a 250 mL polyethylene terephthalate (PET) bottle.
- 30 mL of scintillation mineral oil is added to 250 mL bottle, head space free.
- Sample is shaken for 4 min, and then left to stand until water and mineral oil separate.
- Mineral oil is extracted using pipettes, and transferred to 22 mL glass bottle in the field.



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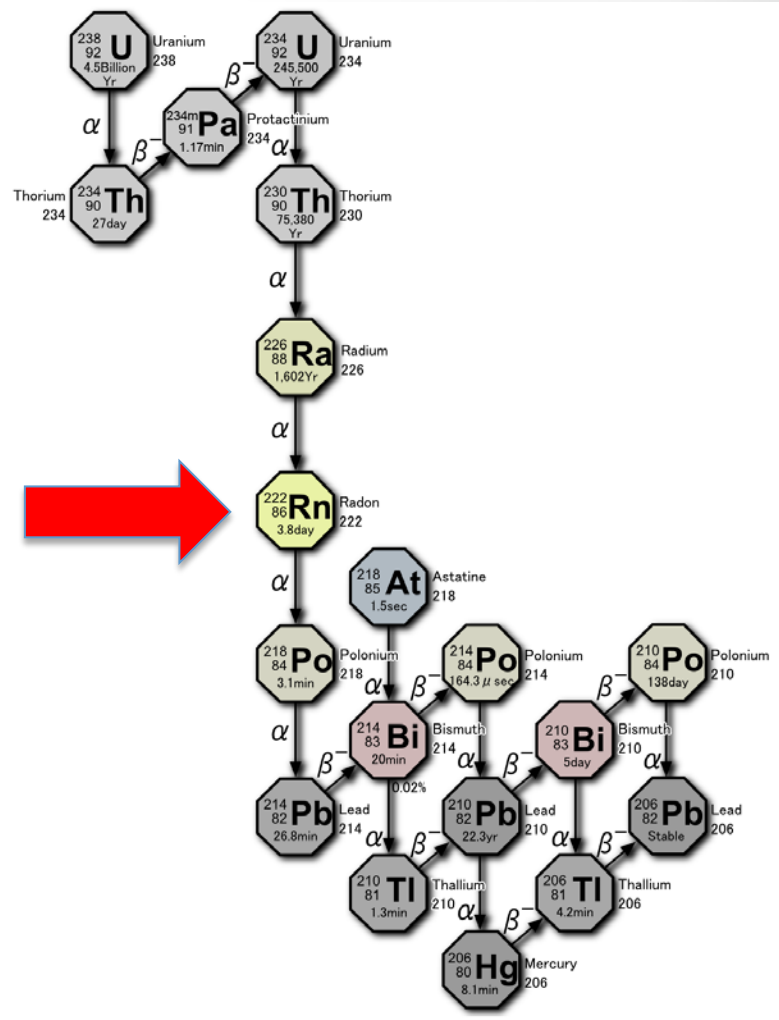
3. Diffusion Sampler Method

- A silicon tube attached to sealed copper tubing was filled with ~12 mL of mineral oil and submerged in water for 30 hrs.
- The diffusion sampler was then quickly retrieved from the drill hole and the mineral oil was transferred to a translucent 22 mL glass bottle.



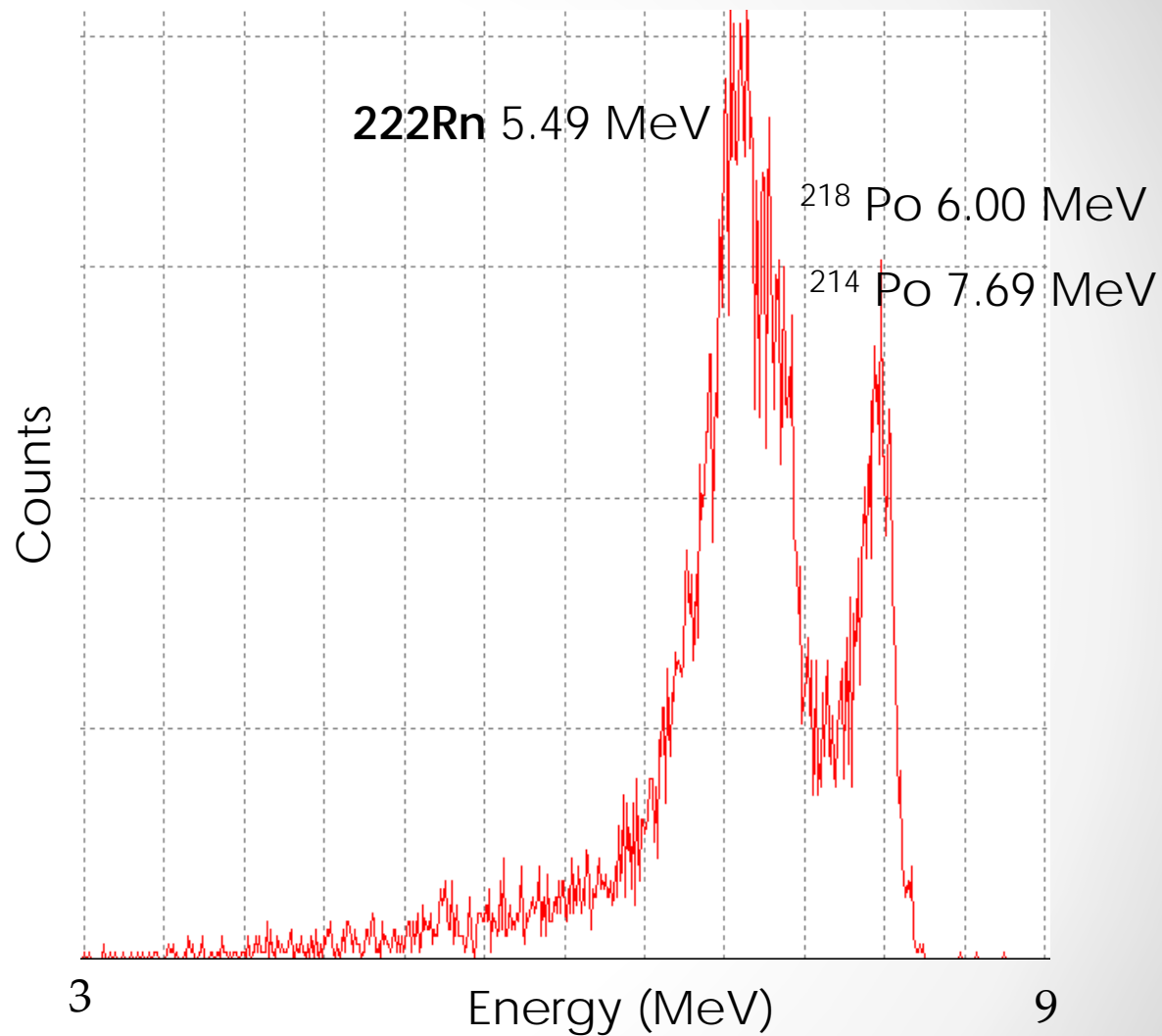
Liquid Scintillation Counting

- Radon is a noble gas with three natural radioactive isotopes ^{219}Rn , ^{220}Rn and ^{222}Rn .
- ^{222}Rn has the longest half life
= 3.82 days
- Produced by radioactive decay of ^{226}Ra and is part of the ^{238}U decay series.
- ^{222}Rn emits alpha particles as it decays to ^{218}Po and ^{214}Po



Liquid Scintillation Counting

Emission energy spectrum of a sample (CX-40) shows the alpha particle emission from radon and its decay products.



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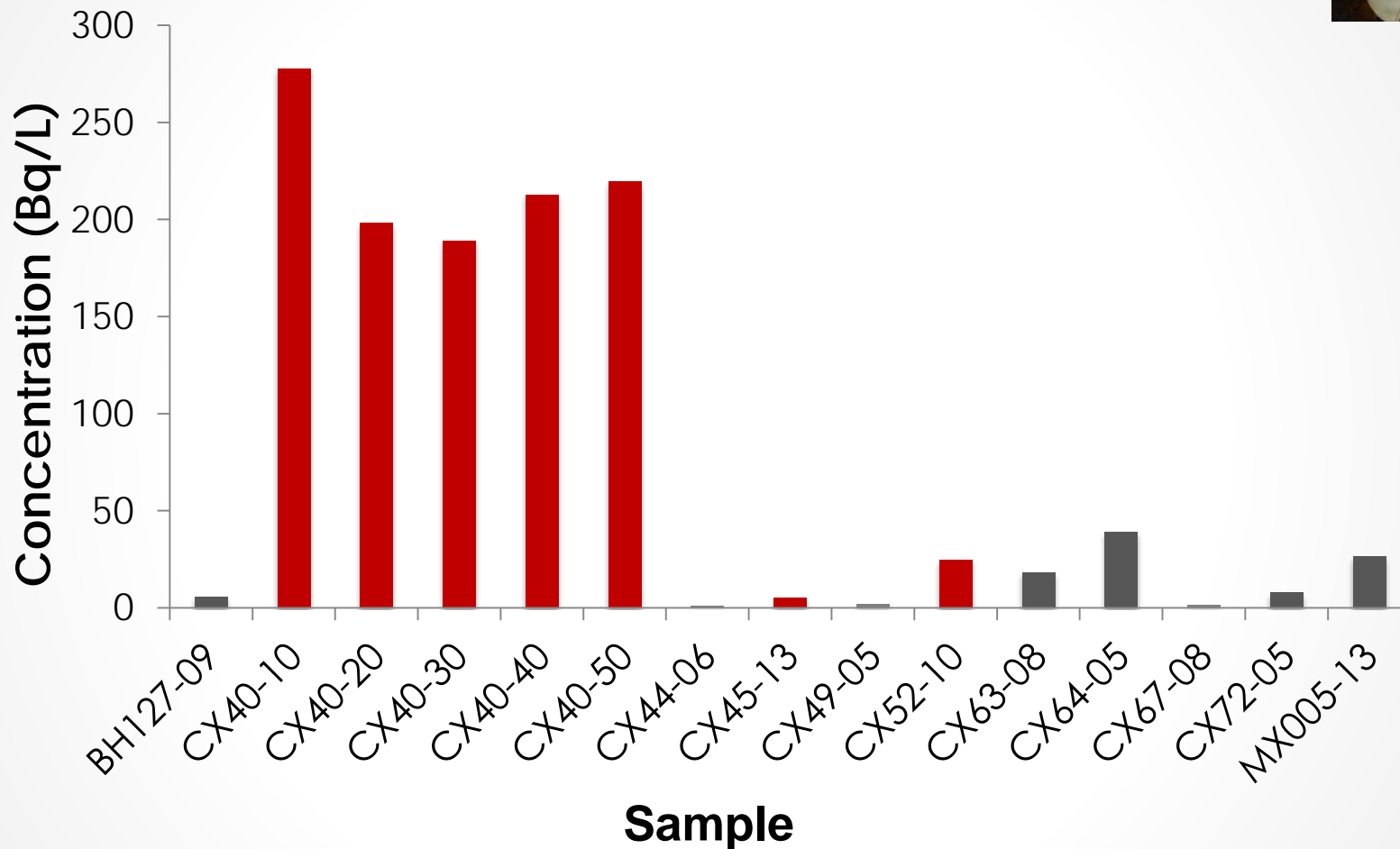
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Radon Concentrations of Groundwater

EM Method



★ Borehole intersects mineralization at depth



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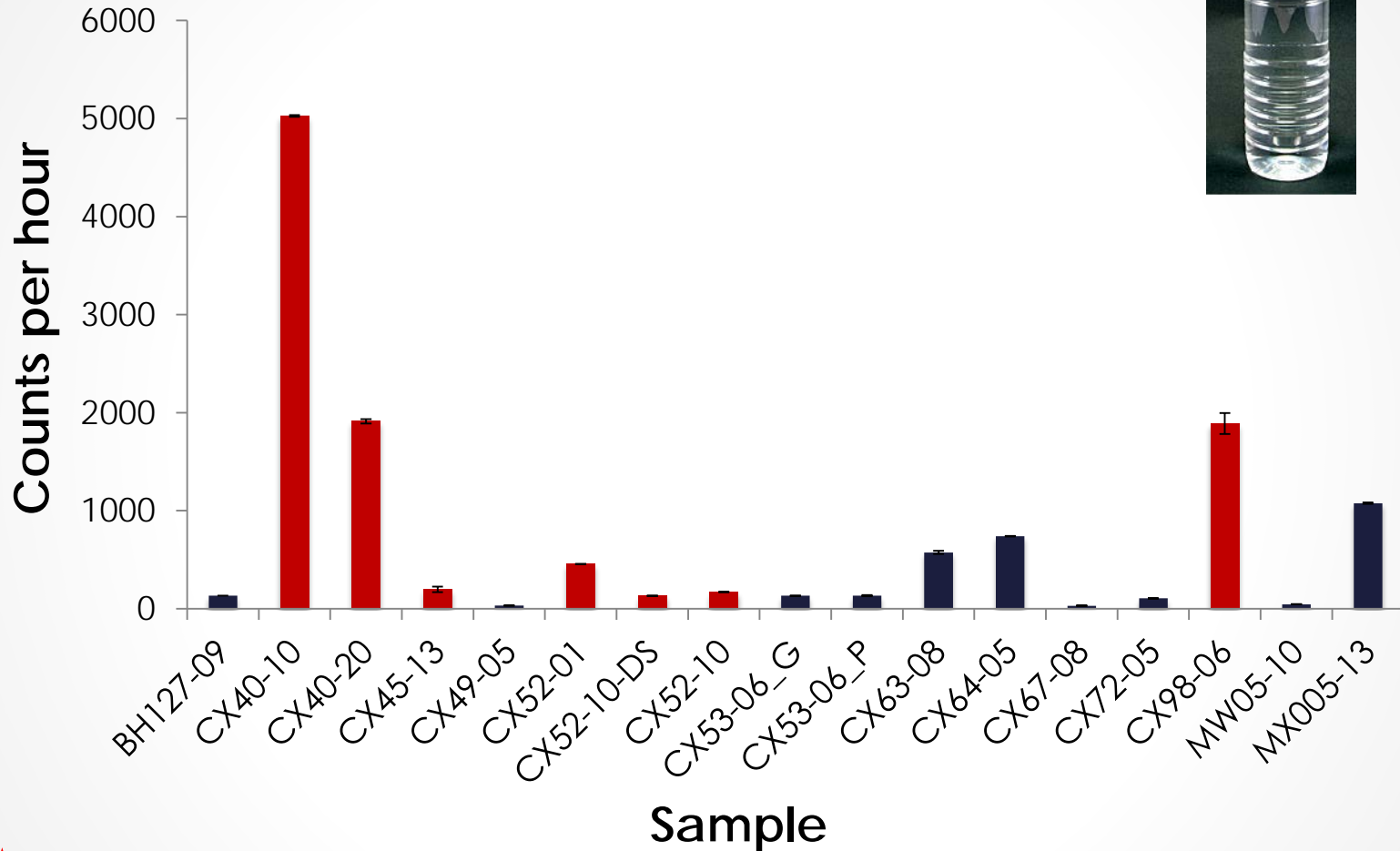
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Alpha Particle Counts of Rn in Oil

PET METHOD



★ Borehole intersects mineralization at depth



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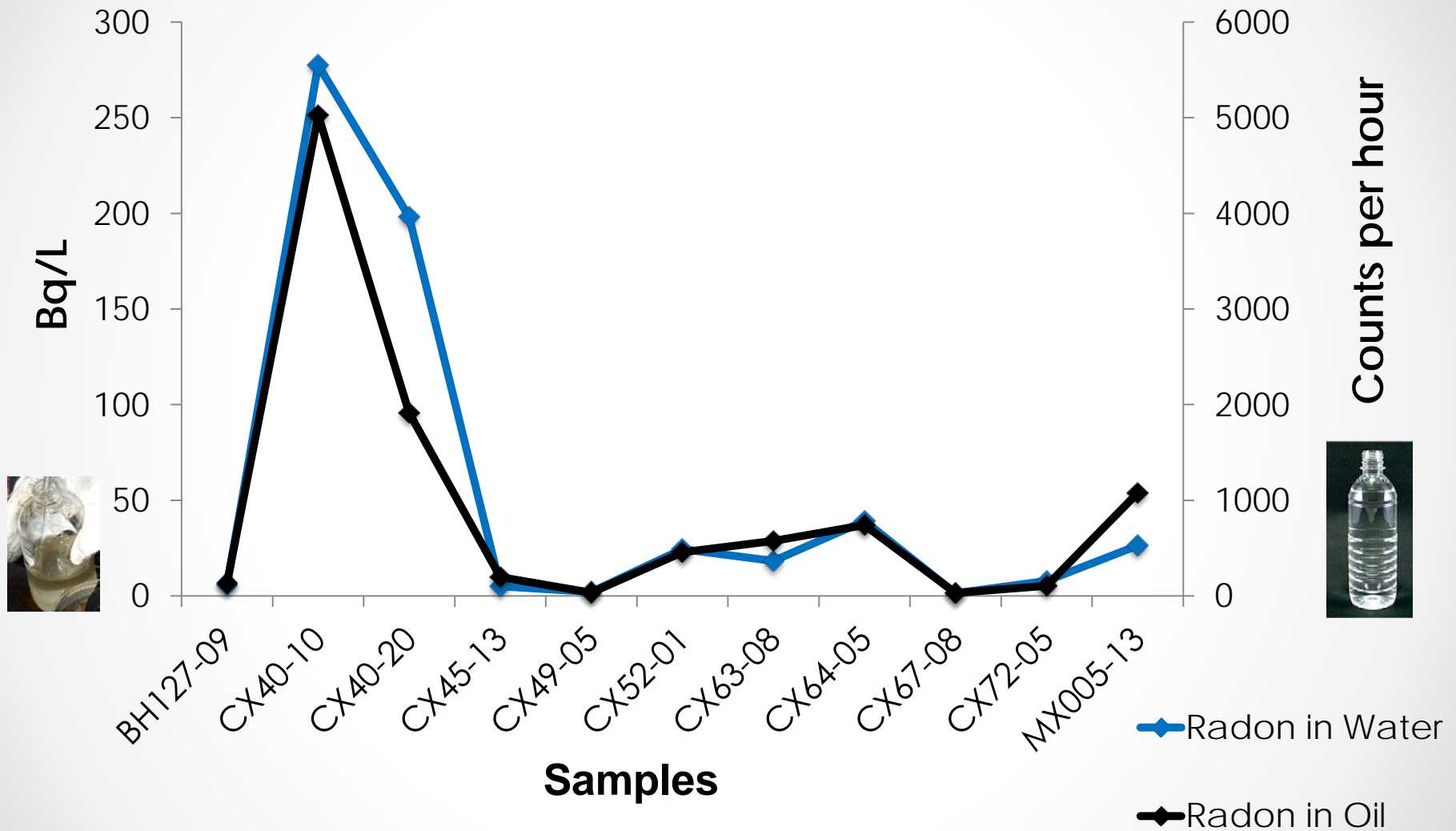


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Rn Analysis Comparison



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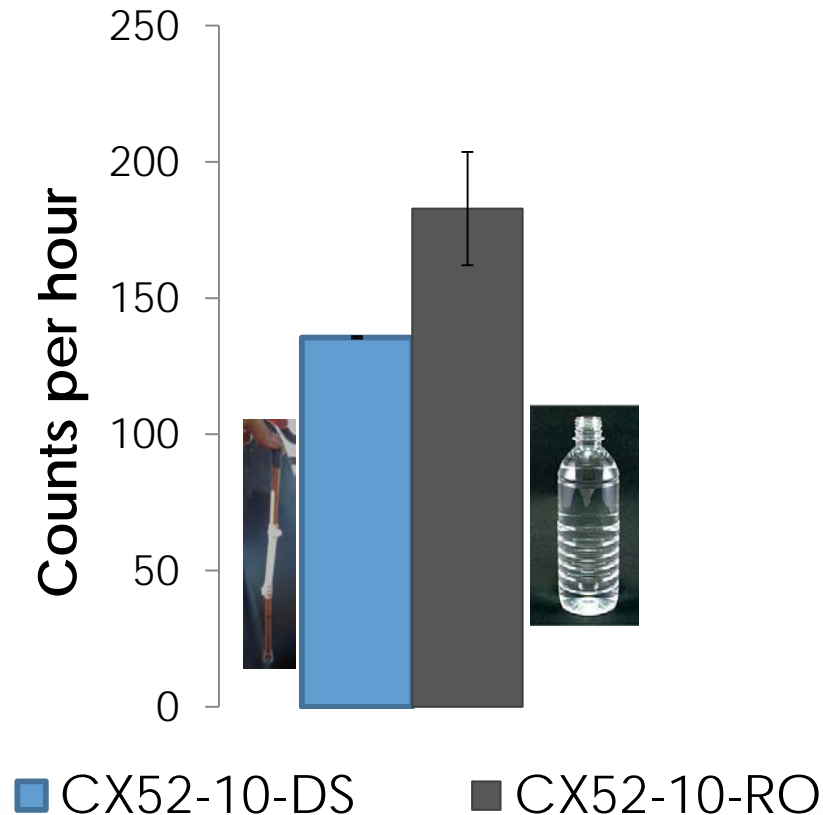


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Diffusion Sampler Method

vs

PET Method

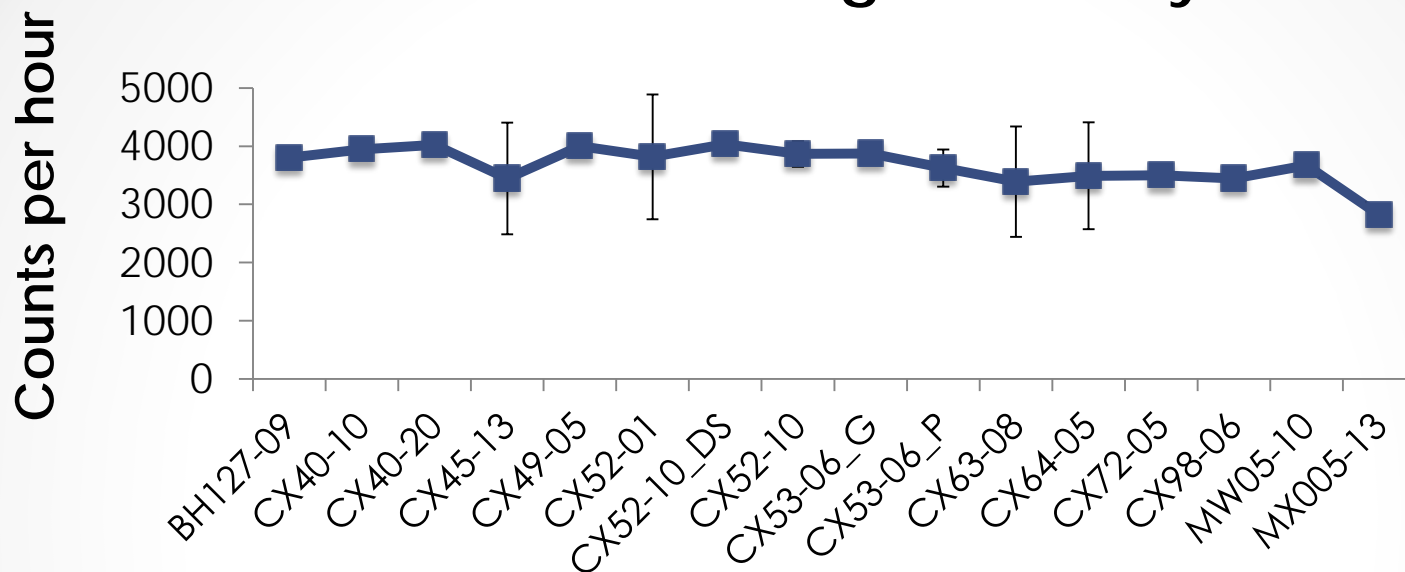


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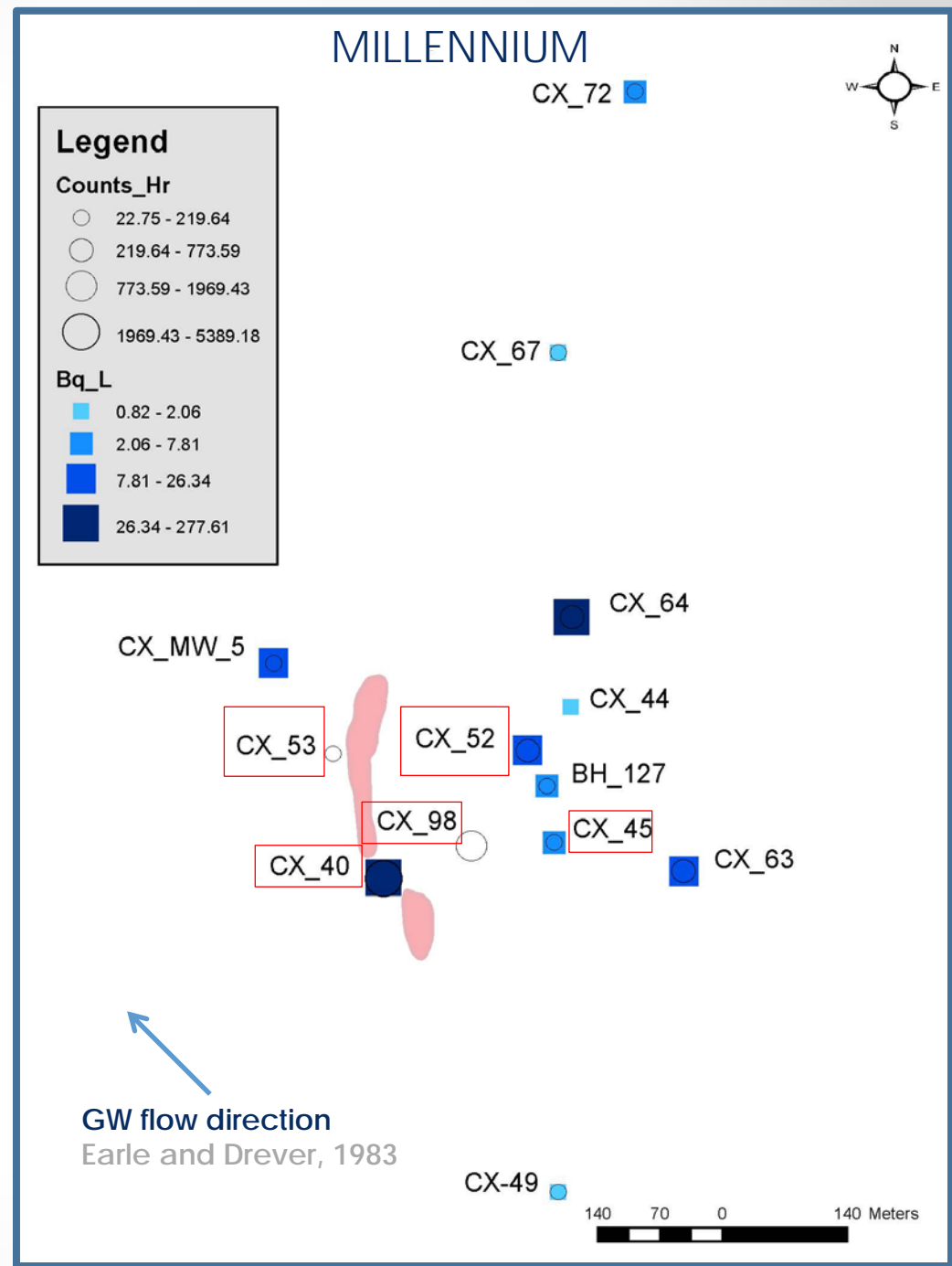
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Do the physical properties of samples affect counting efficiency?

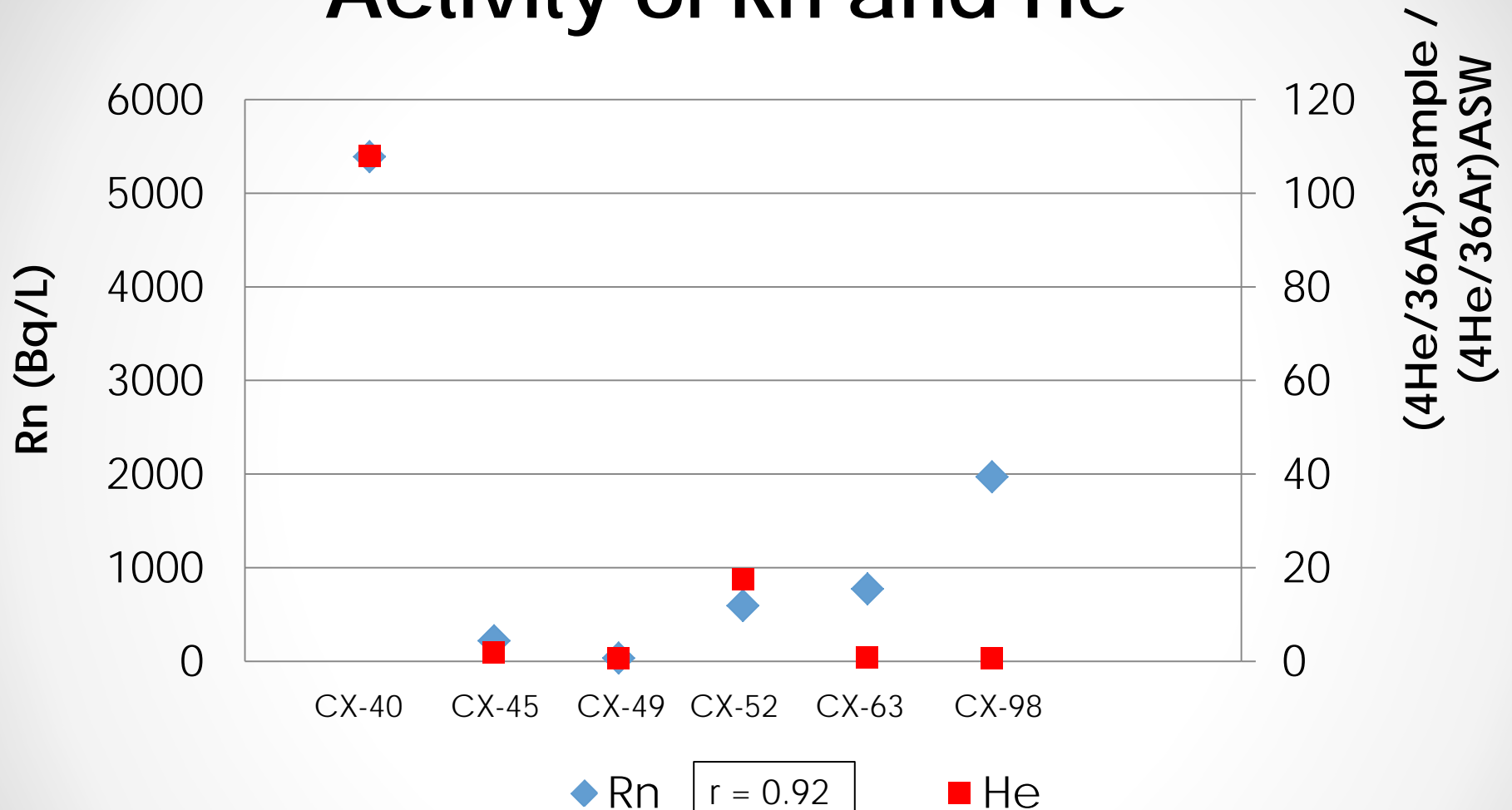


Sample Locations

- Plan view map showing sampling locations and surface projection of ore body.
- All samples in the area of 1.5km x 1km show Rn varying from 0.8 to 277.6 Bq/L.
- Highest Rn activity at CX-40
- Lowest at CX-44 ~ 300 m from the surface projection of the deposit and upslope of groundwater flow.



Activity of Rn and He



Helium data courtesy of Austin Krahenbil - BSc. thesis



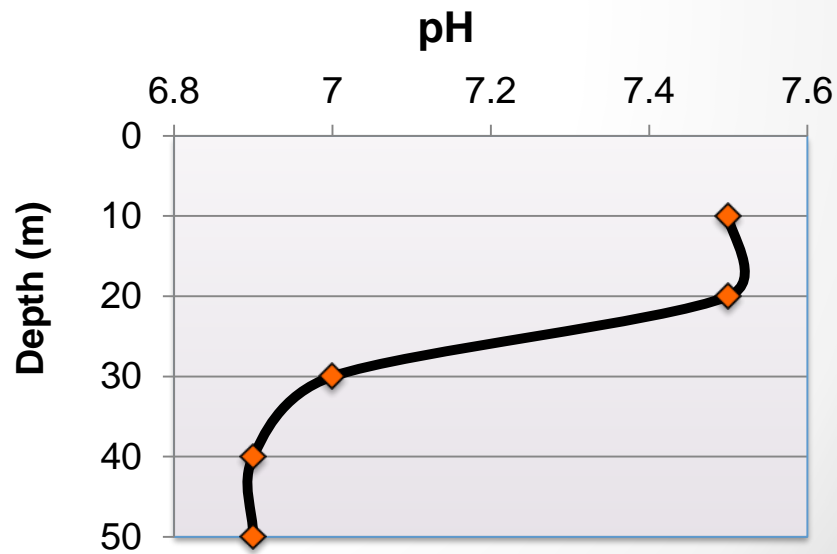
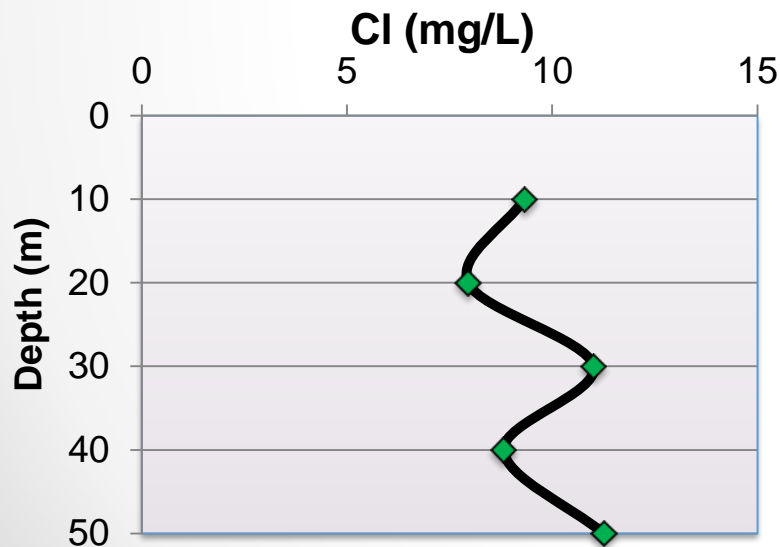
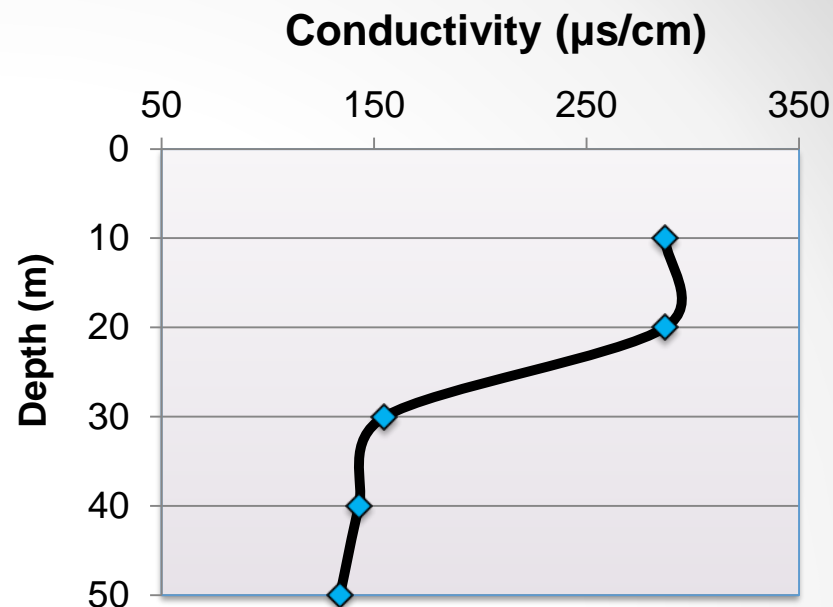
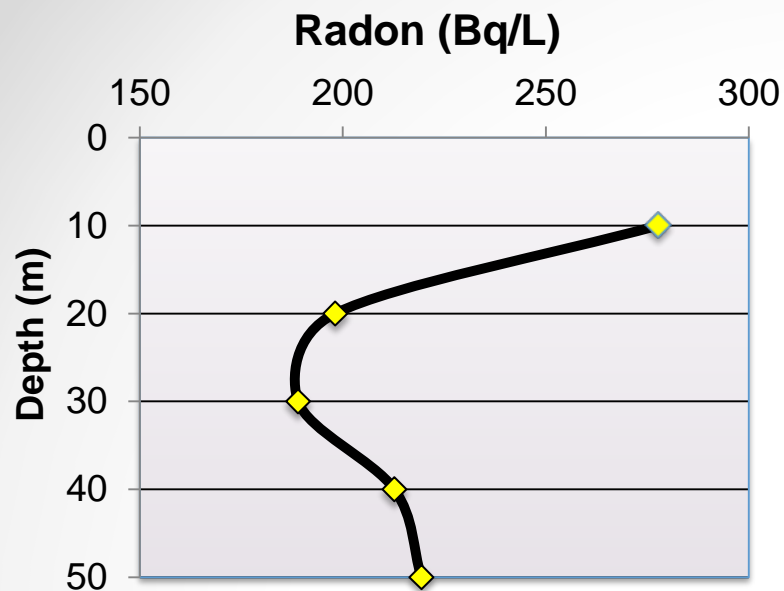
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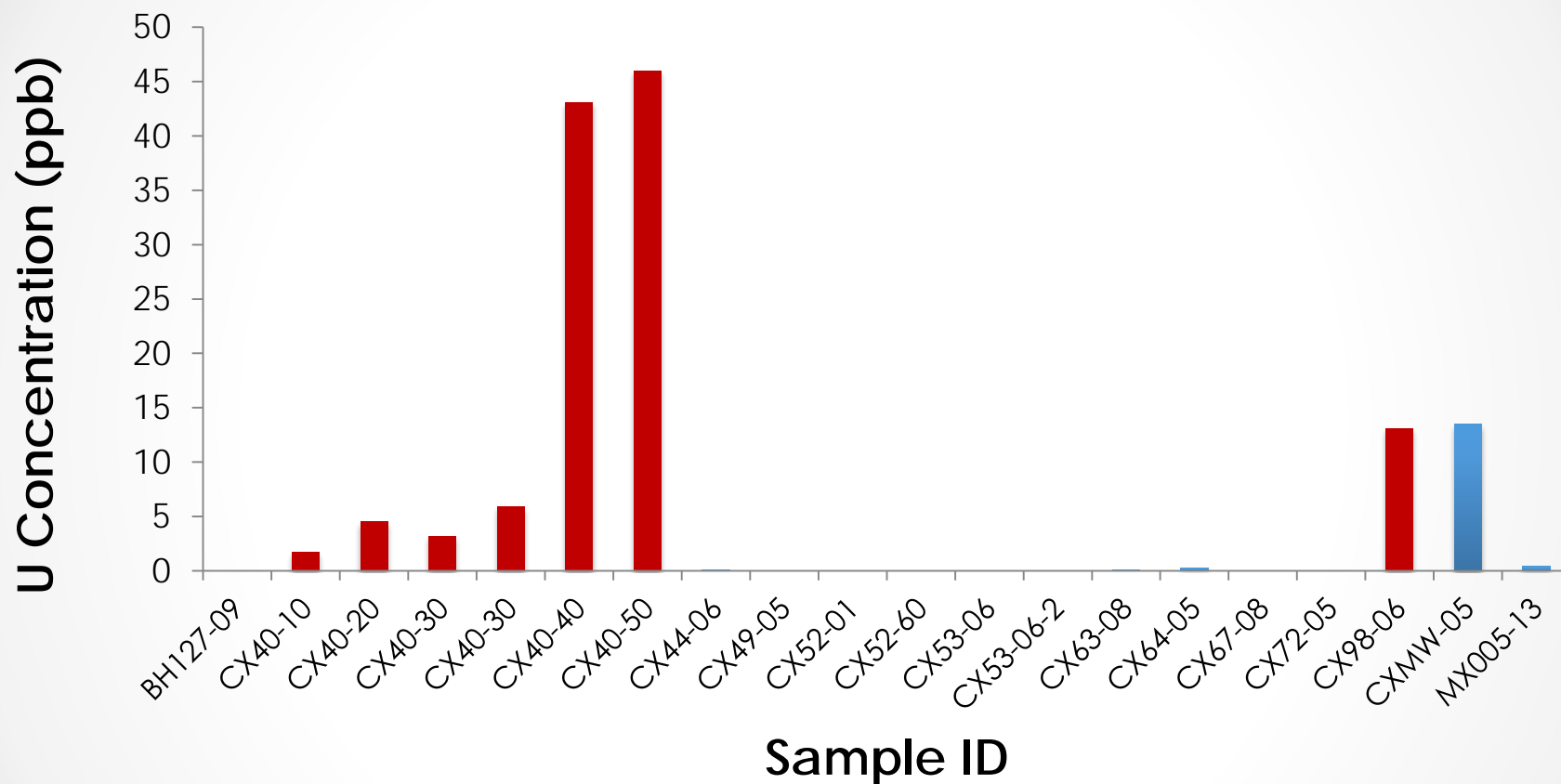
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Total uranium in groundwater



Borehole intersects mineralization at depth

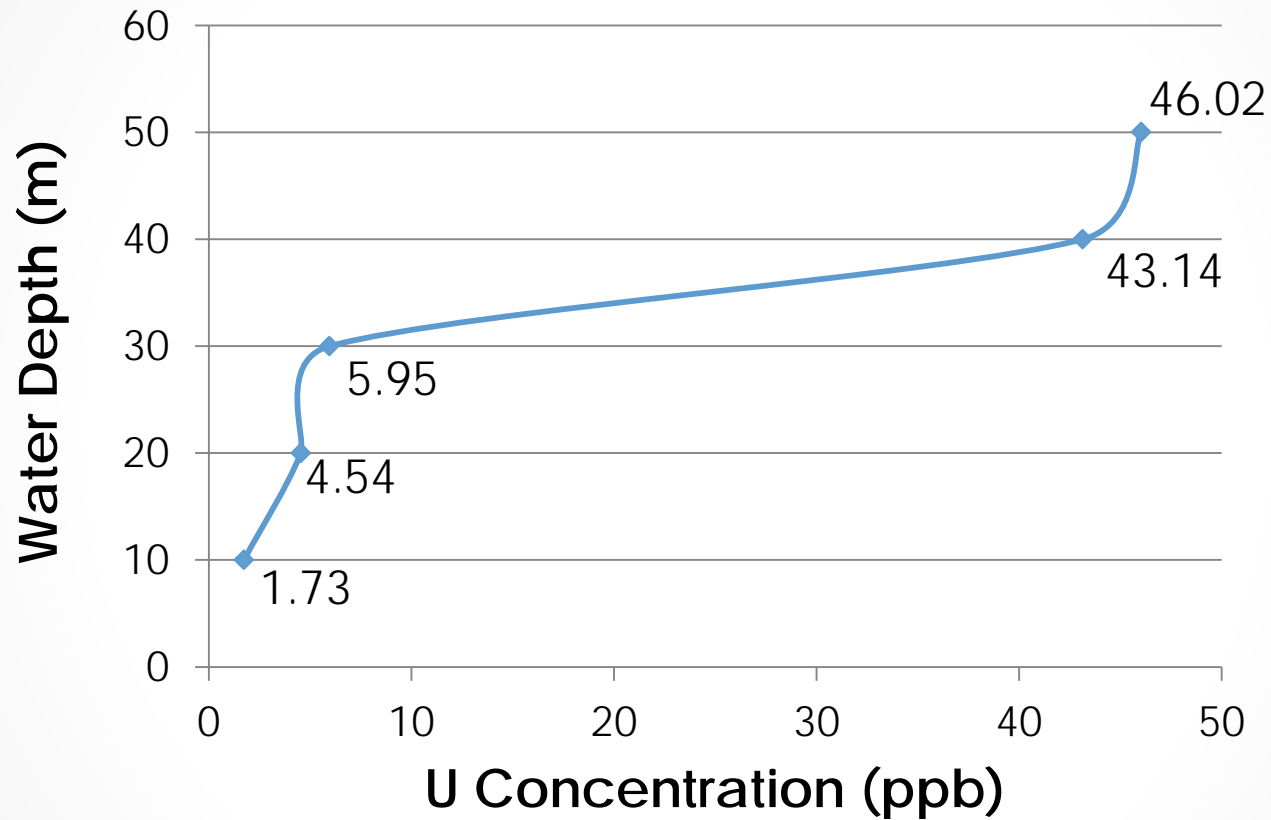


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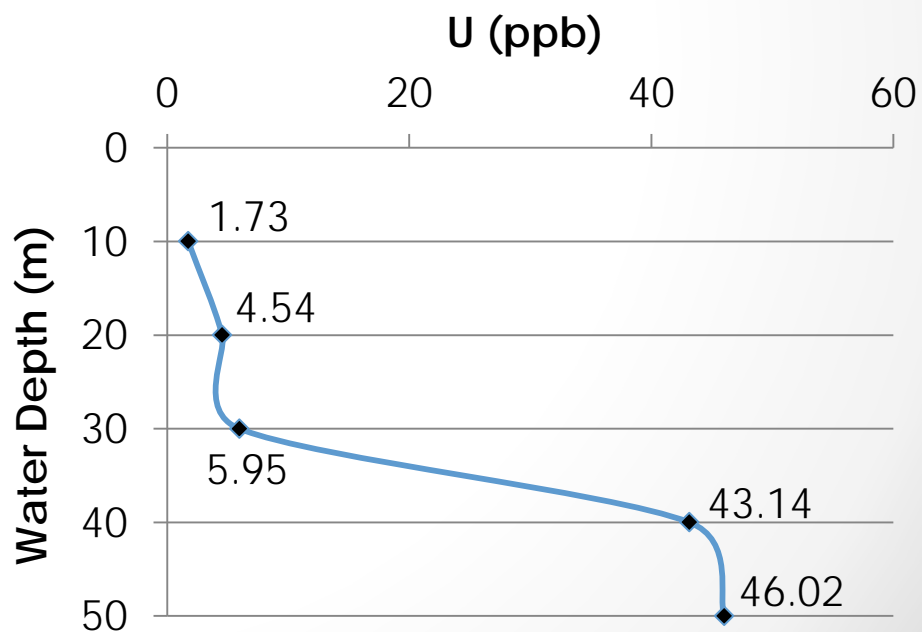
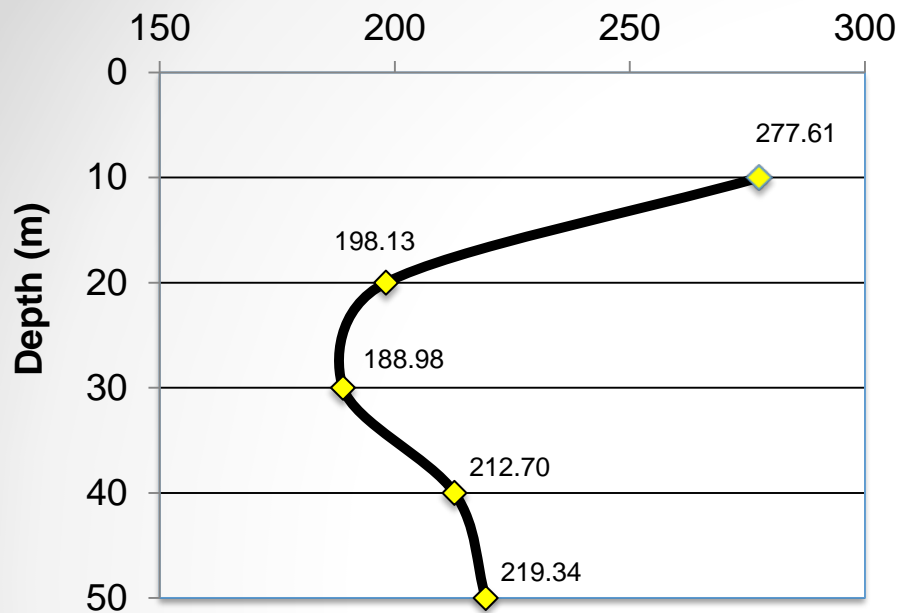


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U Depth Profile - CX-40



Radon (Bq/L)





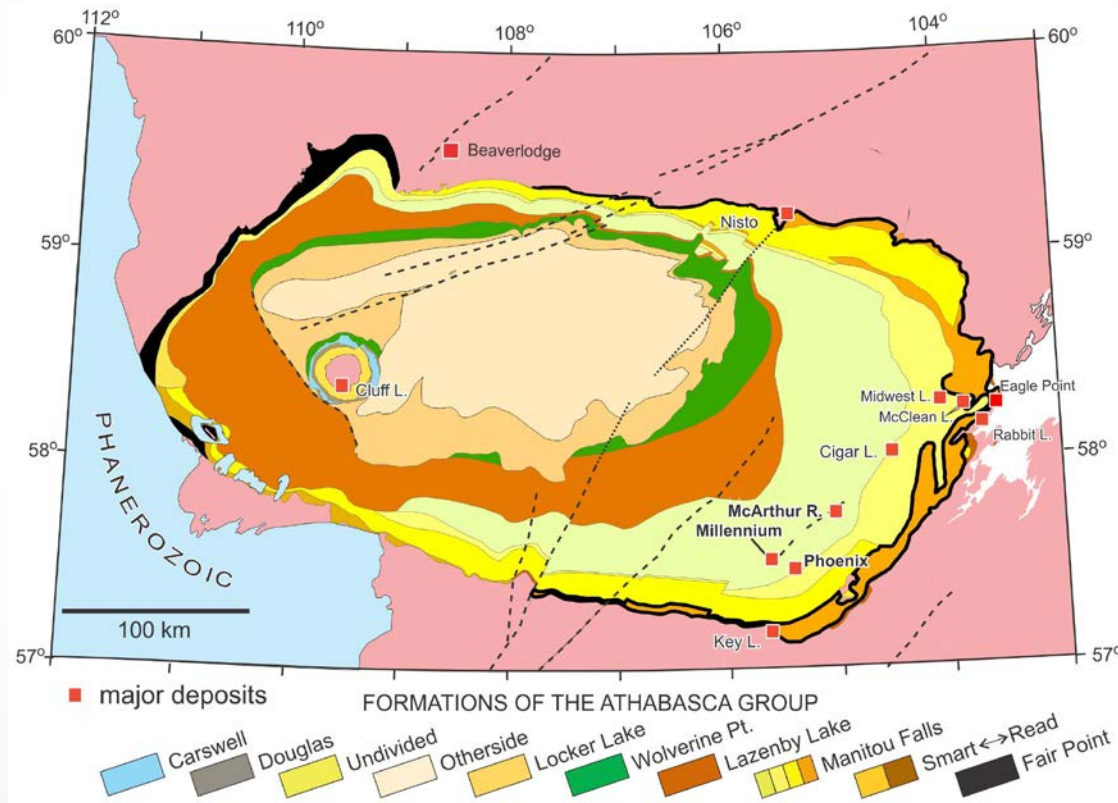
Summary

- All samples show detectable activities of Rn.
- Rn activity was highest at the borehole directly above mineralization
- Lowest at the borehole approximately 300 m from the surface projection of the mineralization.
- A depth profile from 10 m - 50 m of the borehole with highest Rn activity overall has a range in Rn activity from **278 Bq/L at 10 m** to **189 Bq/L at 30 m**.
- The variation in Rn activity does not correlate with pH, conductivity, and halogen contents.
- The measurement of Rn provides information useful in exploring for deeply buried Uranium deposits.



Future Work

- Investigate the structural and hydrogeological influences on groundwater flow at Millennium and McArthur River



Future Work

- Characterize groundwater at Millennium and McArthur River based on major and trace elemental components.
- Determine source of Rn and reasons for varying activity at certain boreholes.

Isotopes	Parameters
O	Temperature
Pb	Conductivity
C	pH
^3H	Eh
Rn, Po	Total DOC

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Questions?



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