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Radon Measurements at the Homestake Mine For Sanford Lab/DUSEL

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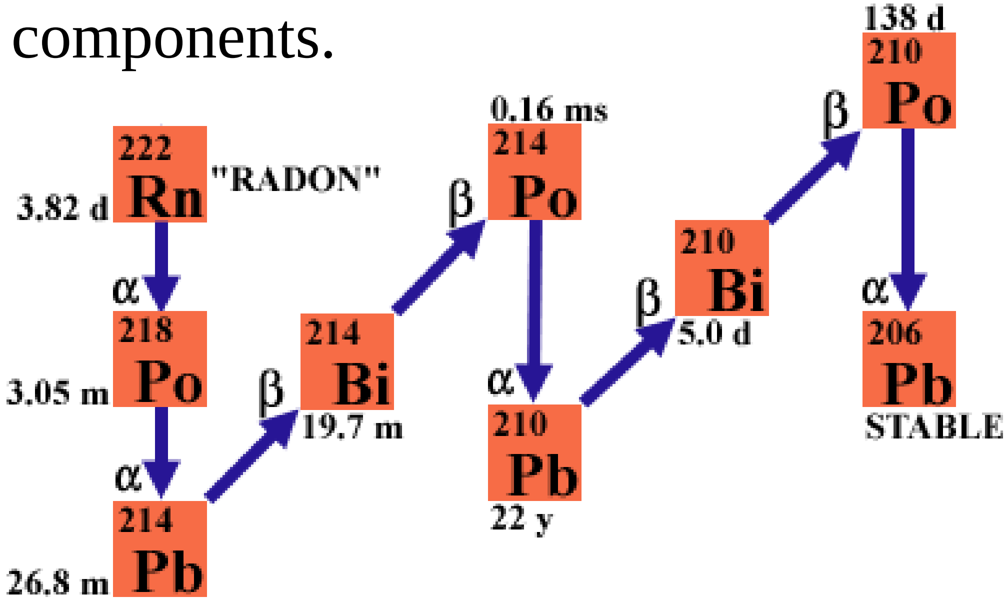
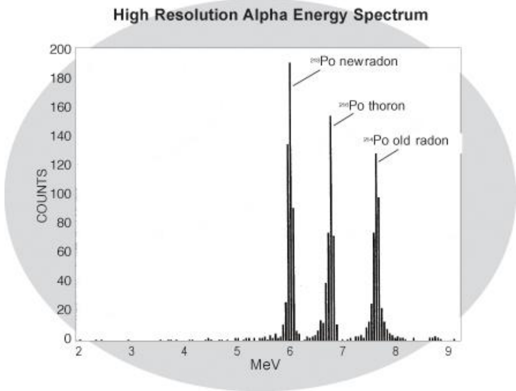
Radon Problems

- Immediate daughters of radon easily ionize and stick to surfaces of materials (plate-out) or attach to aerosols which then stick to surfaces (deposition).
- Immediate daughters are short lived, but introduce a prolonged source of background from ^{210}Pb.
- A possible source of background for sensitive experiments while running, during assembly, and even the counting of detector components.

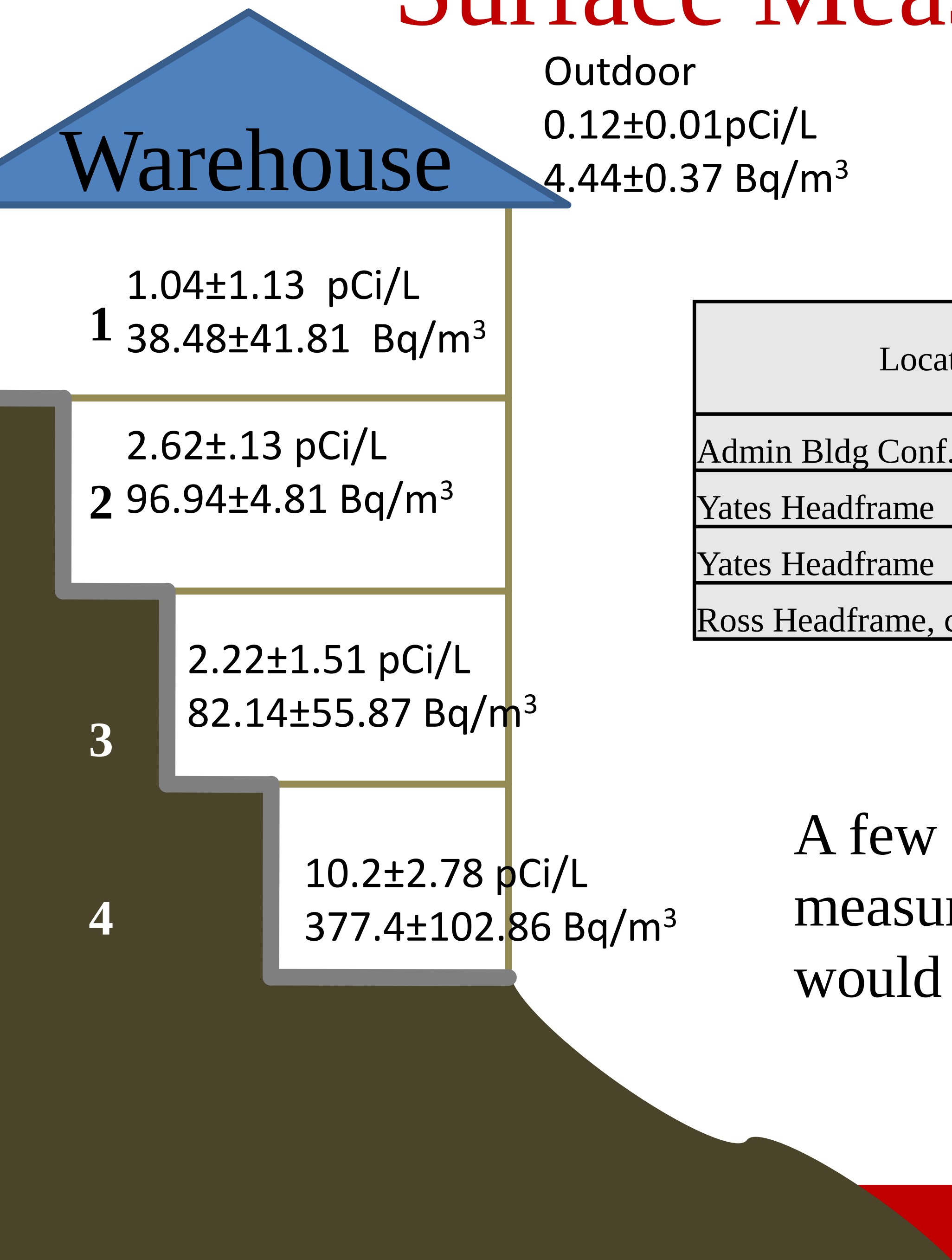


Instruments

- Started (in earnest) in May 09
- Instruments on loan from various institutions and labs.
  - 2-3 Rad7's (USD,Brown, BNL)
  - 3 Alphaguards (LBNL)
- Advantages/Disadvantages for each type of detector.
- Concerns/Limitations underground: humidity, power availability, access



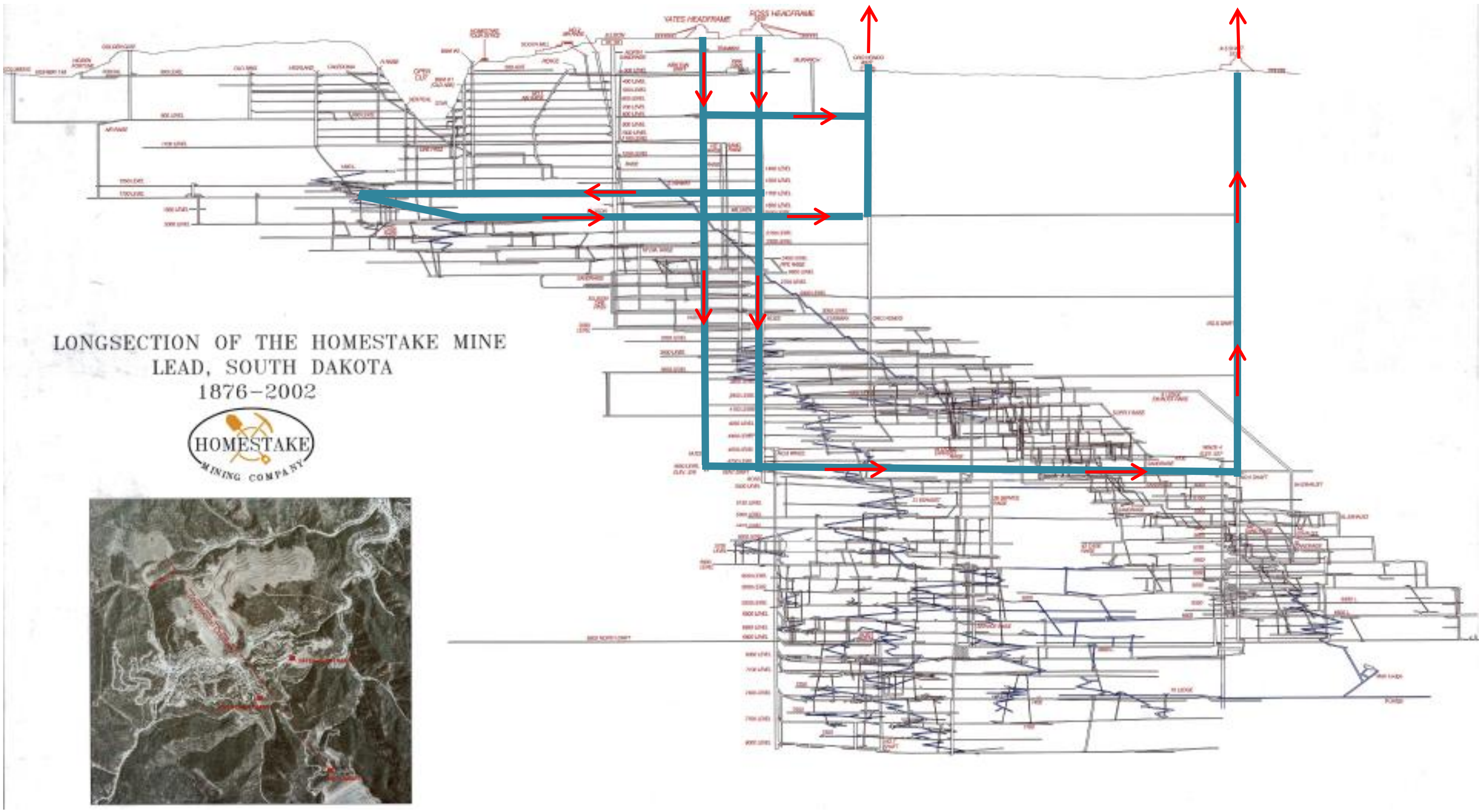
Surface Measurements



Location	Mean Rn Concentration					
	pCi/L			Bq/m^3		
Admin Bldg Conf. Rm, 2nd floor	0.30	+/-	0.81	11.10	+/-	29.97
Yates Headframe	0.28	+/-	0.03	10.36	+/-	1.11
Yates Headframe	0.25	+/-	0.03	9.36	+/-	1.11
Ross Headframe, crusher	0.20	+/-	0.02	7.51	+/-	0.74

A few examples of the surface measurements, typical for what you would expect in surface structures.

Underground Measurements



Underground Measurements

Level	pCi/L	Bq/m^3
Tramway	2.72	100.64
300L	1.77	65.49
800L	1.35 - 12.00	50.00 - 444.00
1250L	1.78 - 25.35	66.00 - 938.00
1400L	1.48 - 18.10	54.76 - 669.70
2000L	17.70 - 30.70	655.00 - 1135.90
4550L	9.07 - 25.40	335.59 - 939.80
4850L	3.86 - 21.97	142.90 - 813.00

→A general range of some of the average values encountered underground.
(not necessarily max or min values, just a few example averages/ballpark values of some tests)

→ Substantial variability attributed to the ventilation.

Historical Measurements

Date	level	WL	1 WL=100 pCi/L=3750 Bq/m^3		1 WL=200 pCi/L=7500 Bq/m^3	
			pCi/L	Bq/m^3	pCi/L	Bq/m^3
7/22/1977	4850L	0.036	3.6	135	7.2	270
7/22/1977	4850L	0.027	2.7	101.25	5.4	202.5
9/28/1977	4850L	0.032	3.2	120	6.4	240
9/28/1977	4850L	0.016	1.6	60	3.2	120
7/14/1977	4850L	0.004	0.4	15	0.8	30
7/15/1977	4850L	0.026	2.6	97.5	5.2	195
7/19/1977	4850L	0.024	2.4	90	4.8	180
9/25/1979	4850L	0.0052	0.52	19.5	1.04	39

100% equilibrium

50% equilibrium

- Our measurements on the 4850L were much higher than what the historical records indicated.
- Rad7 indicated full equilibrium, even in very well ventilated areas.

Factors Affecting Radon

- Ventilation: surface air dilutes and exhausts radon laden air, this can reduce radon in some areas and increase in others.
- Local geology: grain size of rock, porosity, U/Th content and distribution, etc.
- Moisture: Water in pore spaces increases the effective radon emanation coefficient.
- Metal Oxides: weathering process on rock increases porosity of outer surfaces, sorbs Ra and other heavy metals to effectively enrich the oxide layer in Radon parents…

→Ventilation: present capacity reduced compared to past

→Levels below 4550L:

-were/are a little “wet”

-covered by a layer of Iron Oxide sludge/dust

Iron Oxide Sludge Sample

- Sample taken last week and sent to Al Smith for counting at LBNL.
- Both U series, Th series not in equilibrium; in particular due to absorption of Ra-228 and Ra-226 .
- A smaller sample currently being counted indicates the emanation coefficient of the material may be quite high.

SDSTA Iron Oxide Sludge

U(early)	0.68(5)	ppm
U(late)	5.6(1)	ppm
Th(early)	18.(1)	ppm
Th(late)	4.5(1)	ppm
K	0.034(1)	pct

Homestake Country Rock

U	0.08-0.2	ppm
Th	0.2-0.3	ppm
K	0.1-0.15	pct

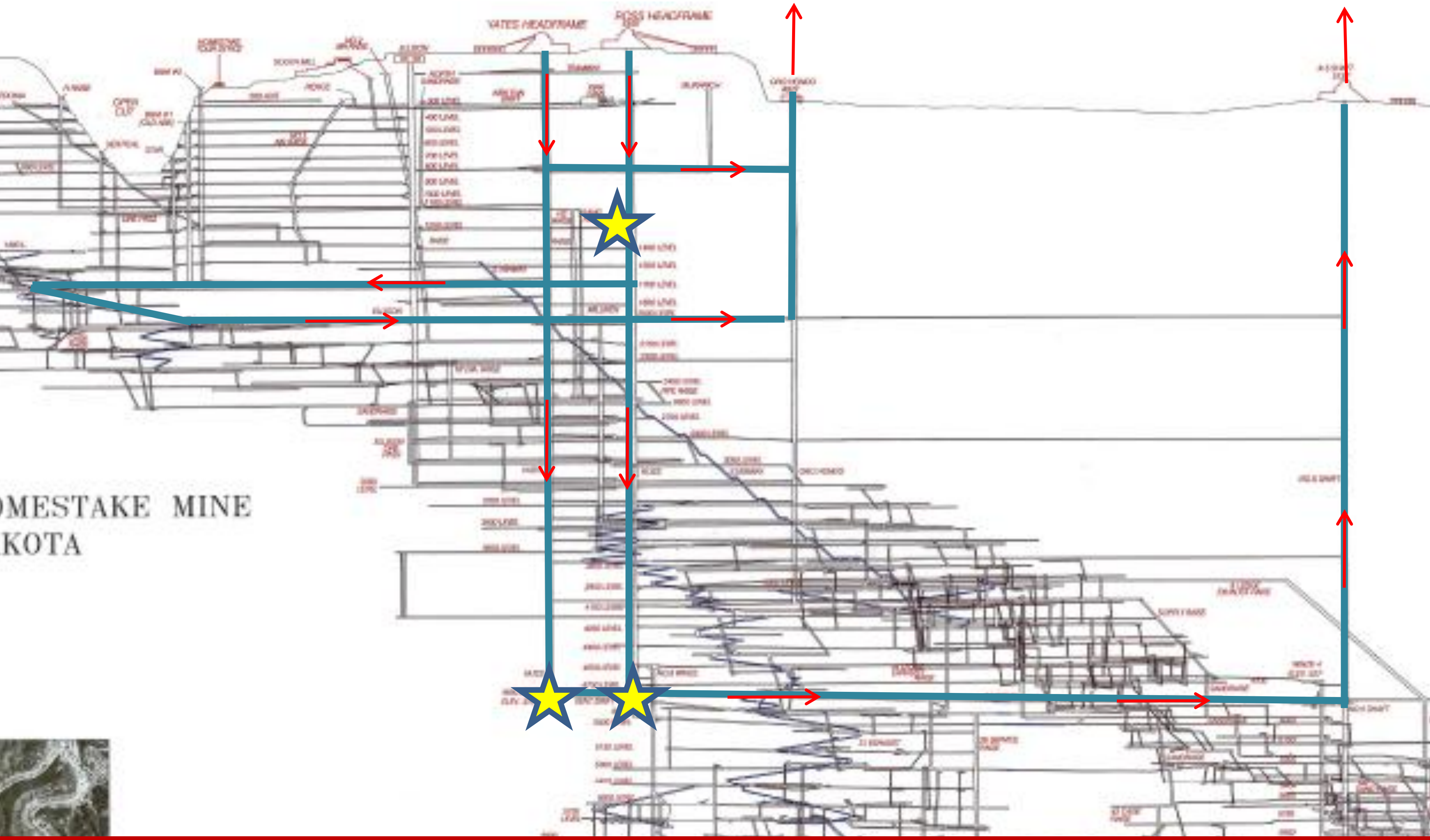
Homestake Rhyolite Intrusives

U	8-10	ppm
Th	8-12	ppm
K	2-4	pct

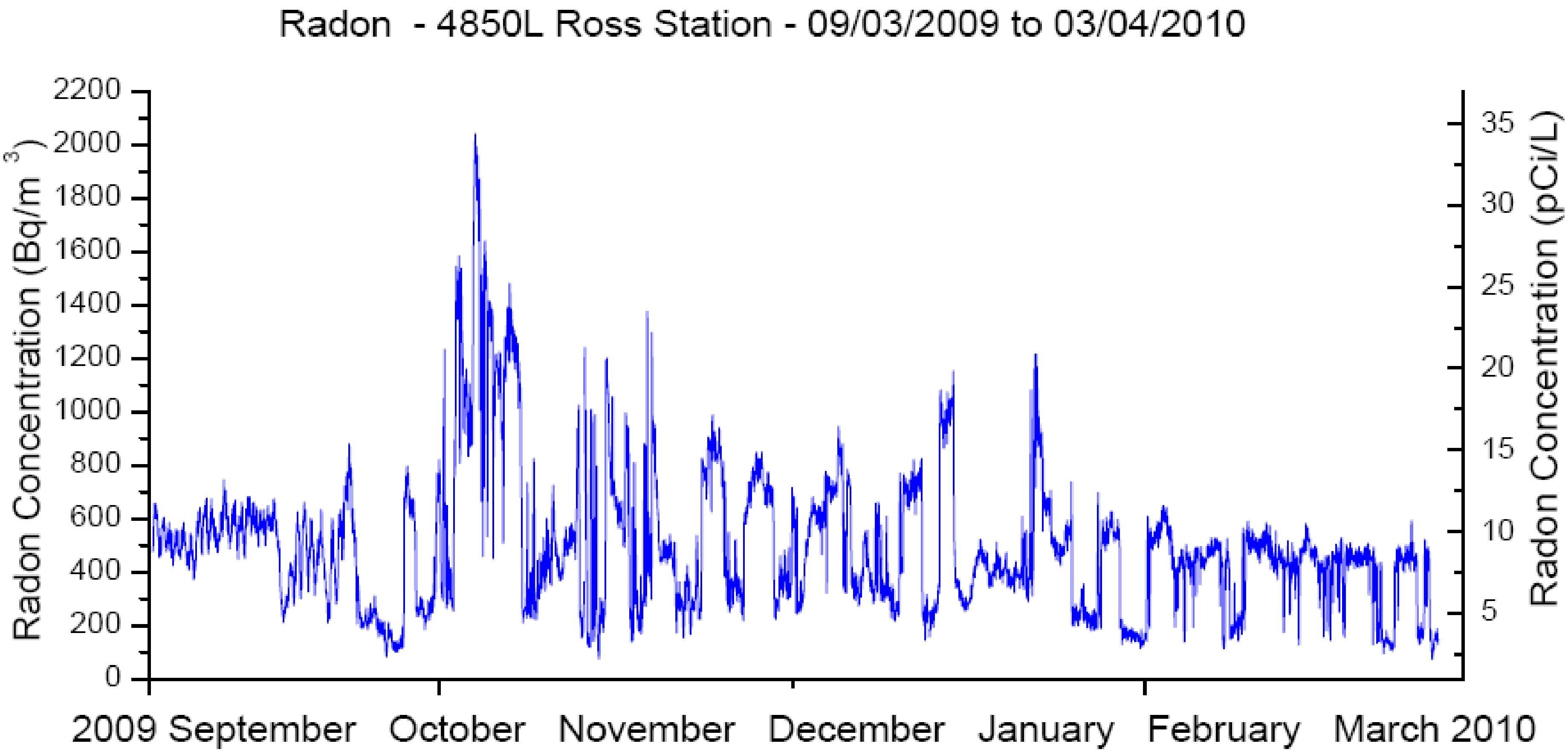
(representative values of Homestake samples counted by Al Smith at LBNL)

Mine Ventilation

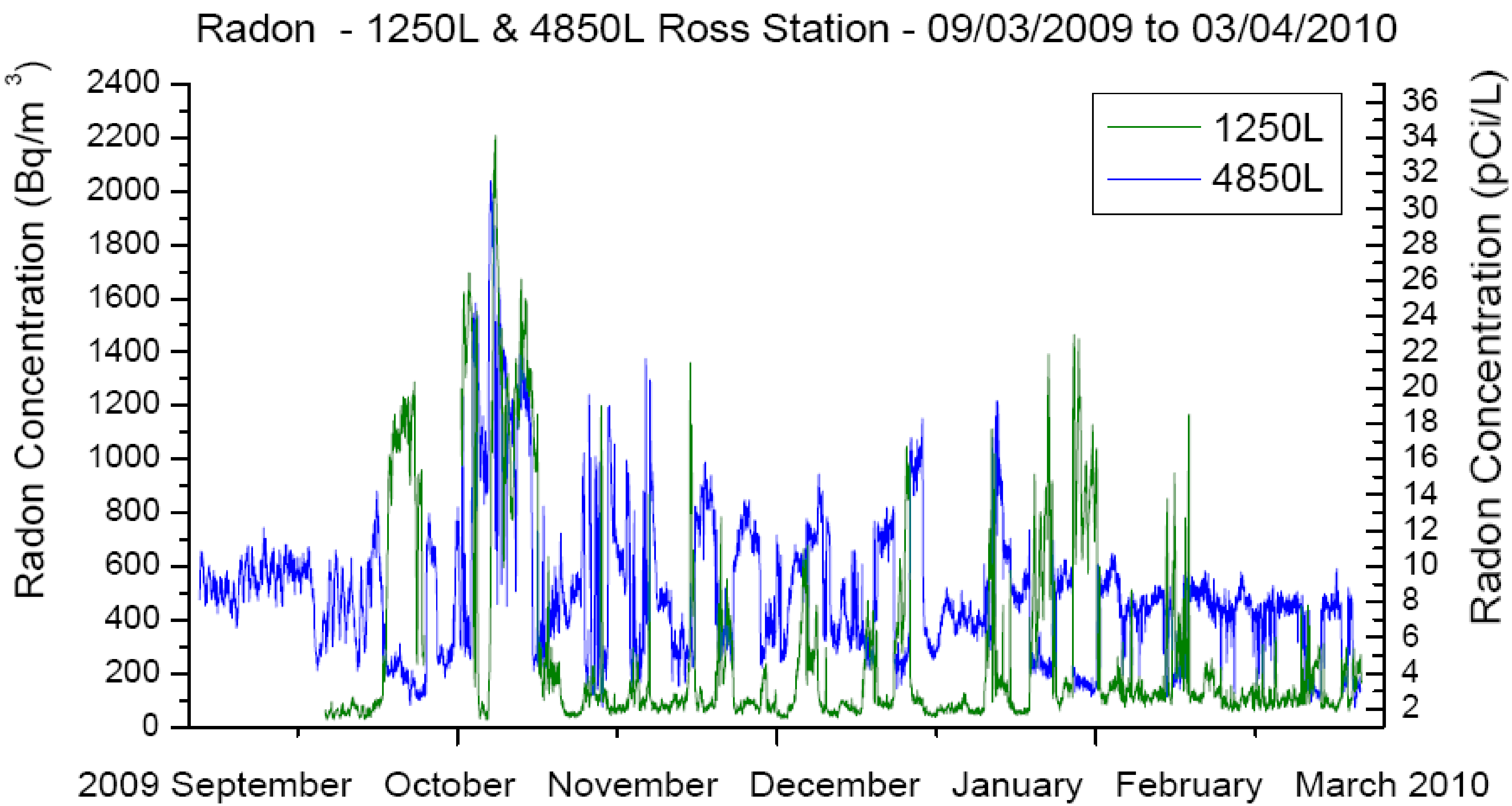
Only 30-50% of Historical Capacity. (and very dynamic)



Long Term Monitoring

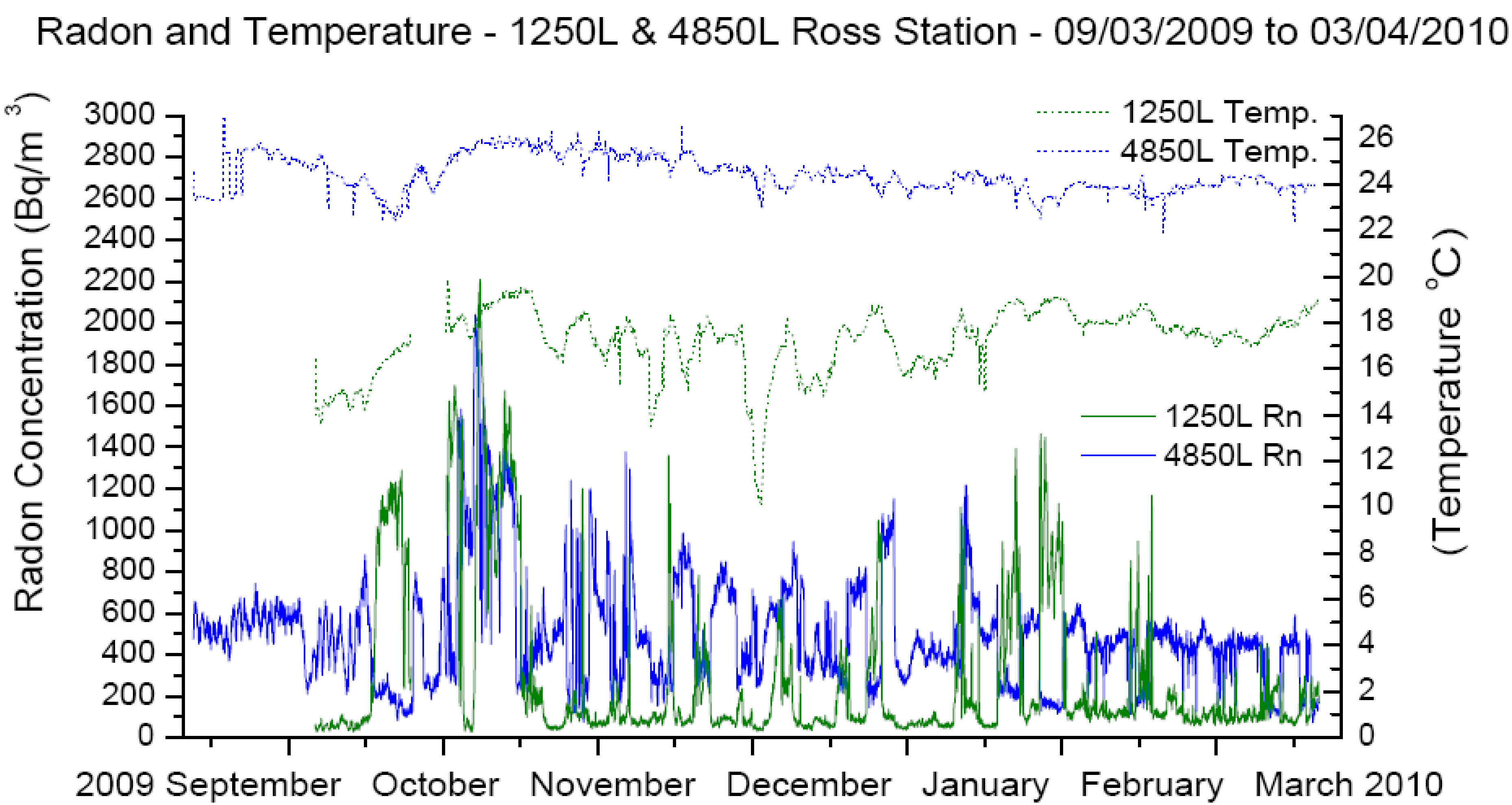


1250L vs 4850L



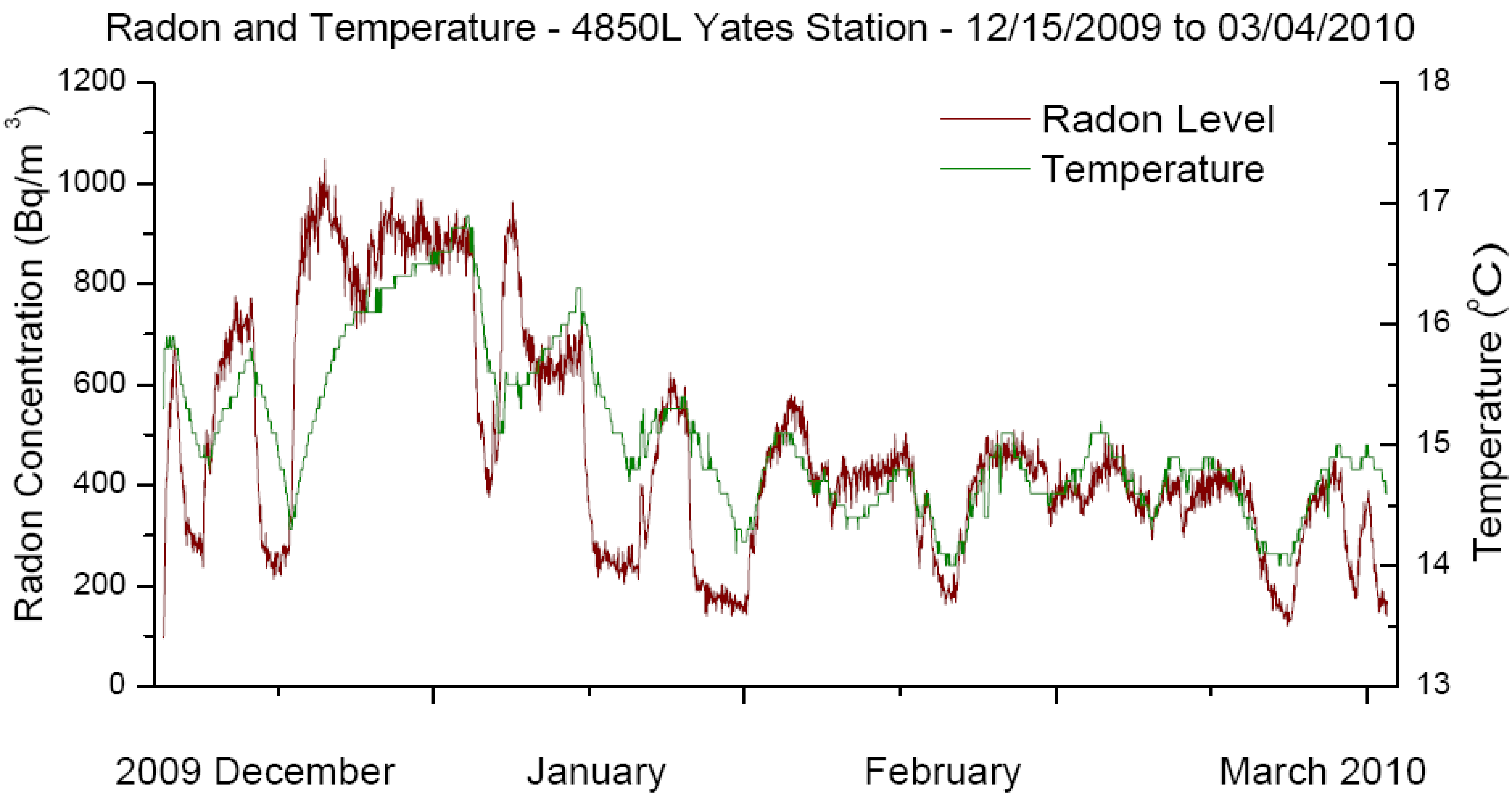
Comparisons of vertical locations on the Ross shaft reveal some ventilation events, such as air direction reversals.

Radon and Temperature



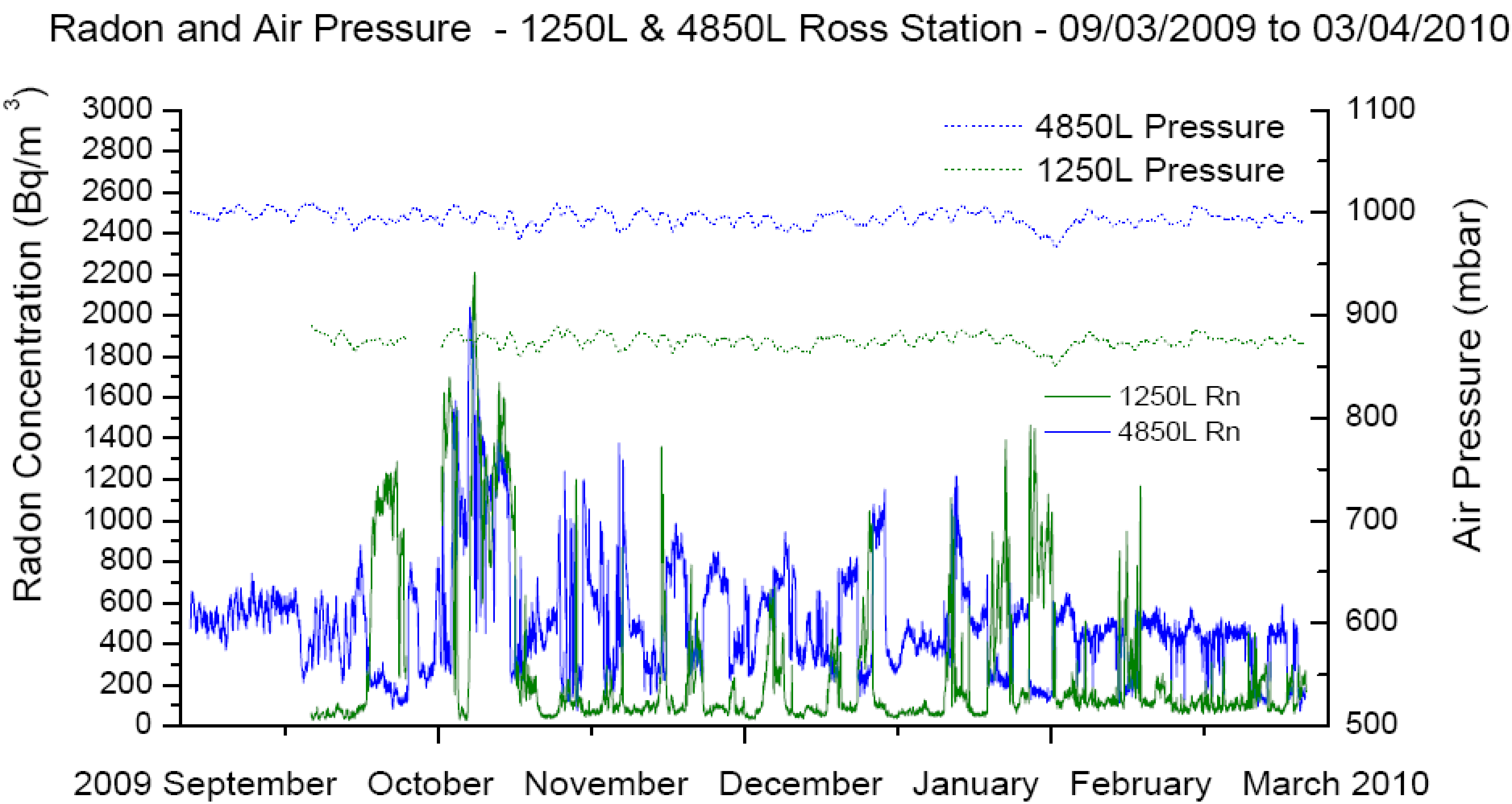
Temperature changes can imply changes in how 'fresh' the air is entering the location.

Yates Station Rn vs. Temp.

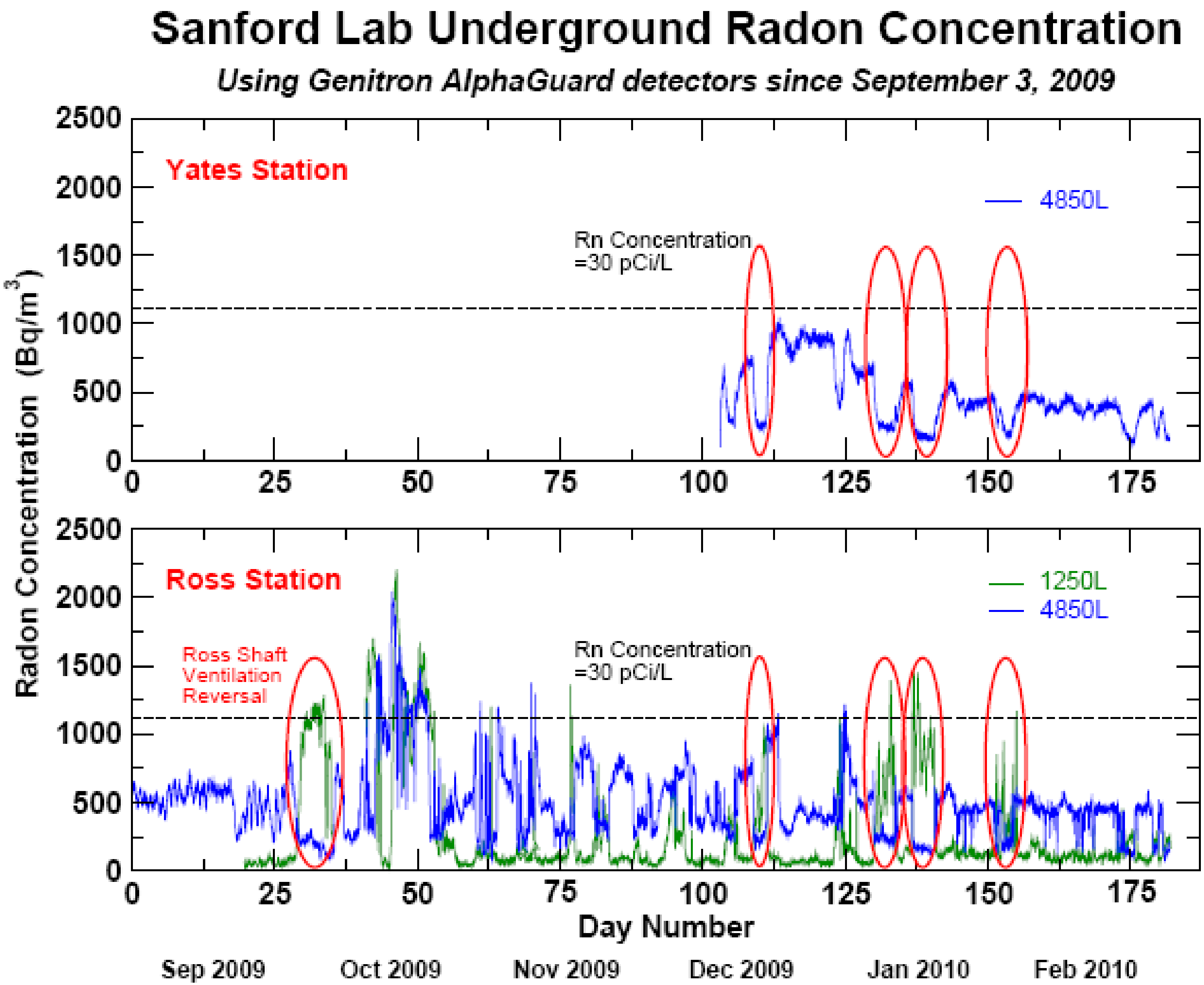


The temperature relationship clearer at the 4850L Yates location is more evident, where the ventilation is less chaotic.

Air Pressure



Pressure dependencies are unrelated to ventilation, radon– but show clear relationships to elevation and (presumably) the local weather.



Some events understood or accounted for, others not.

Summary

- Measurements underground reflect radon levels with little or no mitigation efforts in place: minimal/unstable ventilation (30-50% of historical capacity), no layers resistant to diffusion, no radon removal systems.
- Measurements reflect relationship of radon with exposure to surface area of rock– i.e. air direction reversals in Ross Shaft.
- Moisture in the rock, presence of iron oxide may play a role in enhancing the radon levels on the 4850L, and others that were dewatered.
- Improvements to the ventilation system, receding water levels will change the ventilation conditions underground and therefore also the radon levels.
- Long term measurements still running on the 1250L/4850L Ross Stations, 4850L Yates. Would like to add a surface location as well.