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RADON AND DUST MEASUREMENTS - JULY 1990
SUDBURY NEUTRINO OBSERVATORY SITE

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Report SNO-STR

INTRODUCTION:

To establish design criteria for the air conditioning/ filtration system for the observatory, levels of airborne dust and radon typically found in the vicinity of the underground site must be evaluated. This report gives the results of radon and dust measurements made during three visits to the SNO underground site at the Creighton Mine, in June and July, 1990, and updates data from a previous report (1) on measurements made in 1988.

1. RADON AND RADON DECAY PRODUCTS IN MINE AIR

Radon measurements were made at several locations on the 6800 ft level of the Creighton mine, near the observatory drift entrance. A portable radon monitor (Pylon Model R2000) was used with 160 mL scintillation cells (for radon counts) or a 30 mm scintillator tray, for radon product counts from 25 mm 0.8 micron air filters. Radon levels (pCi/L) and decay product levels (in Working Level units WL) are listed in Tables 1 and 2.

Table 1: Airborne Radon Levels

(a) Mine Air Sampling

Date	Location	Cell #	Background (cpm)	Net Counts (cpm)	R(Rn)* (pCi/L)
June 28	1	2	0.875	1.83	2.99
June 19	2	3	0.775	2.475	4.5 +/- 0.6
June 28	2	1	1.05	1.17	2.0 +/- 0.4
July 12	2	1	1.05	1.80	2.9 +/- 0.4
June 28	3	3	0.775	2.58	4.1 +/- 0.1
July 12	3	2	0.55	2.80	3.4 +/- 0.3

* corrected to activity at the end of the sampling period

(b) Borehole Radon levels

July 12	4	4 **	0.675	12.5	
July 12	5	5 **	0.825	13.0	

** 220 mL cells used

Note that the activity R(Rn) = (cpm)/K.(cell volume) pCi/L, where the counts/min is signal - background. The cell efficiency K is about 4.0 cpm/pCi for each cell.

Table 2: Airborne Radon Decay Products (working level units)*

Date	Location	Filter #	Air Volume(L)	Filter cpm	Time (t) (min)	W.L.	F
June 28	1	2	80	27.75	44	0.0065	0.21
June 19	2	2	150	38.0	40	0.0067	0.15
June 28	2	1	150	18.75	69	0.0037	0.19
July 12	2	1	390	63.75	63	0.0041	0.14
June 28	3	3	100	44.25	45	0.0084	0.20
July 12	3	2	194	23.5	89	0.0052	0.15

*1 working level (W.L.) is the activity of decay products when 100 pCi/L Rn222 is in equilibrium with its decay products.

W.L. = R(net filter) /(Air volume x K(t) x E)
where R is the filter activity at time t after sampling
K(t) is the Kusnetz correction factor at t
E is the scintillator tray efficiency = 0.384

F = 100 x W.L./R(Rn) is an equilibrium factor, measuring decay product loss through ventilation or plate-out.

The above tables indicate that measured radon and radon decay product levels at the various sites and times are quite consistent and typical of a well-ventilated non-uranium mine. Average values of 3.3 +/- 0.8 pCi/L for radon activity and 0.0058 +/- 0.0016 W.L. for radon decay product activity were calculated, where the uncertainty represents the standard deviation of the measurements. An average equilibrium factor F = 0.18 was found, indicating a high percentage of decay product removal.

Borehole radon concentrations were determined by sealing off two blind holes in the SNO washstation area (dimensions 2" diamete x 12 ft deep) with rubber stoppers, for a 10 day period. An evacuated scintillator cell (220 mL volume) was connected to a tube through the stopper, and after purging, a sample of borehole air was collected in the cell and counted. For norite rock with a typical uranium content of 1.2 ppm (micrograms/gram), 7060 Rn atoms per gram of rock should be present if equilibrium exists. For 1 cubic meter of rock (density 2870 kg/cubic m), a radon activity of 2.55 x 10E6 dpm is expected. Given the activities listed in Table 1b (13.0 cpm), the borehole surface area (0.584 square m) and a cell efficiency of about 0.6, the diffusion depth for radon from the norite can be estimated. The resulting depth d = 0.16 mm appears to be quite reasonable, although clearly this value is sensitive to the fractures and surface conditions of the surrounding rock.

2. AIRBORNE DUST MEASUREMENTS

The dust size and concentration in typical mine air on the 6800 ft level was measured at the same sites as the radon sampling Measurements of air loading (mg/cubic m air) for dust in 6 size ranges from < 0.05 microns to > 3.2 microns aerodynamic diameter,

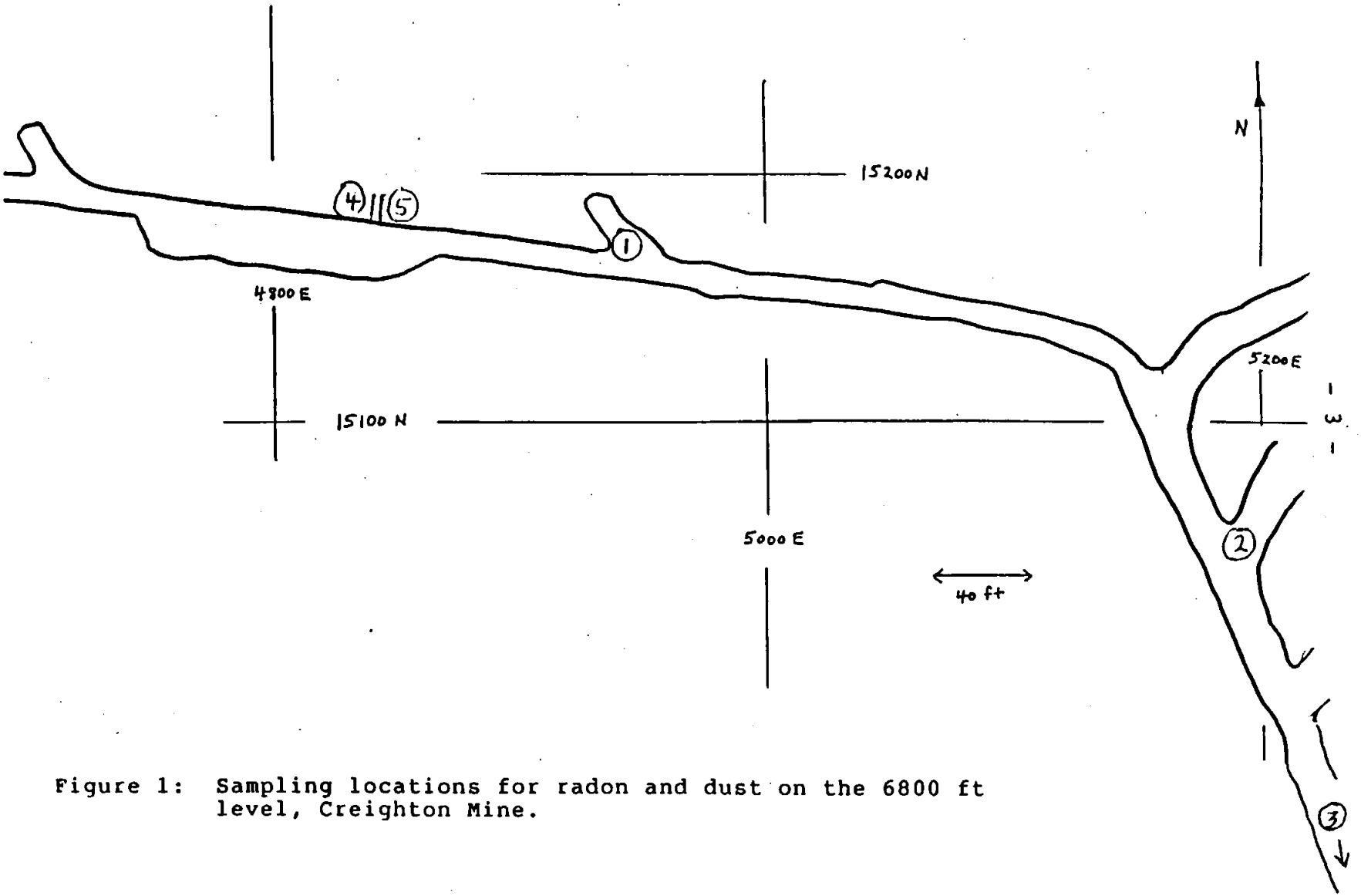

Figure 1: Sampling locations for radon and dust on the 6800 ft level, Creighton Mine.

CREIGHTON MINE DUST MONITORING RESULTS

TABLE 3
Location 1 Electrical Switch Room

Impactor Stage i	D(50) (μm)	Particle Concentration C(i) (mg/m^3) June 28/90	July 12/90
1	3.20	0.223	N/A
2	1.32	0.417	N/A
3	0.58	0.153	N/A
4	0.26	0.049	N/A
5	0.12	0.026	N/A
6	0.05	0.024	N/A
	Total	0.892	

TABLE 4
Location 2 Power Station

Impactor Stage i	D(50) (μm)	Particle Concentration C(i) (mg/m^3) June 28/90	July 12/90
1	3.20	0.150	0.054
2	1.32	0.241	0.035
3	0.58	0.109	0.017
4	0.26	0.039	0.008
5	0.12	0.042	0.032
6	0.05	0.010	0.035
	Total	0.591	0.181

R = 3.26

TABLE 5
Location 3 Old Ore Pass

Impactor Stage i	D(50) (μm)	Particle Concentration C(i) (mg/m^3) June 28/90	July 12/90
1	3.20	0.144	0.051
2	1.32	0.070	0.014
3	0.58	0.049	0.009
4	0.26	0.017	0.005
5	0.12	0.007	0.005
6	0.05	0.014	0.002
	Total	0.301	0.086

R = 3.5

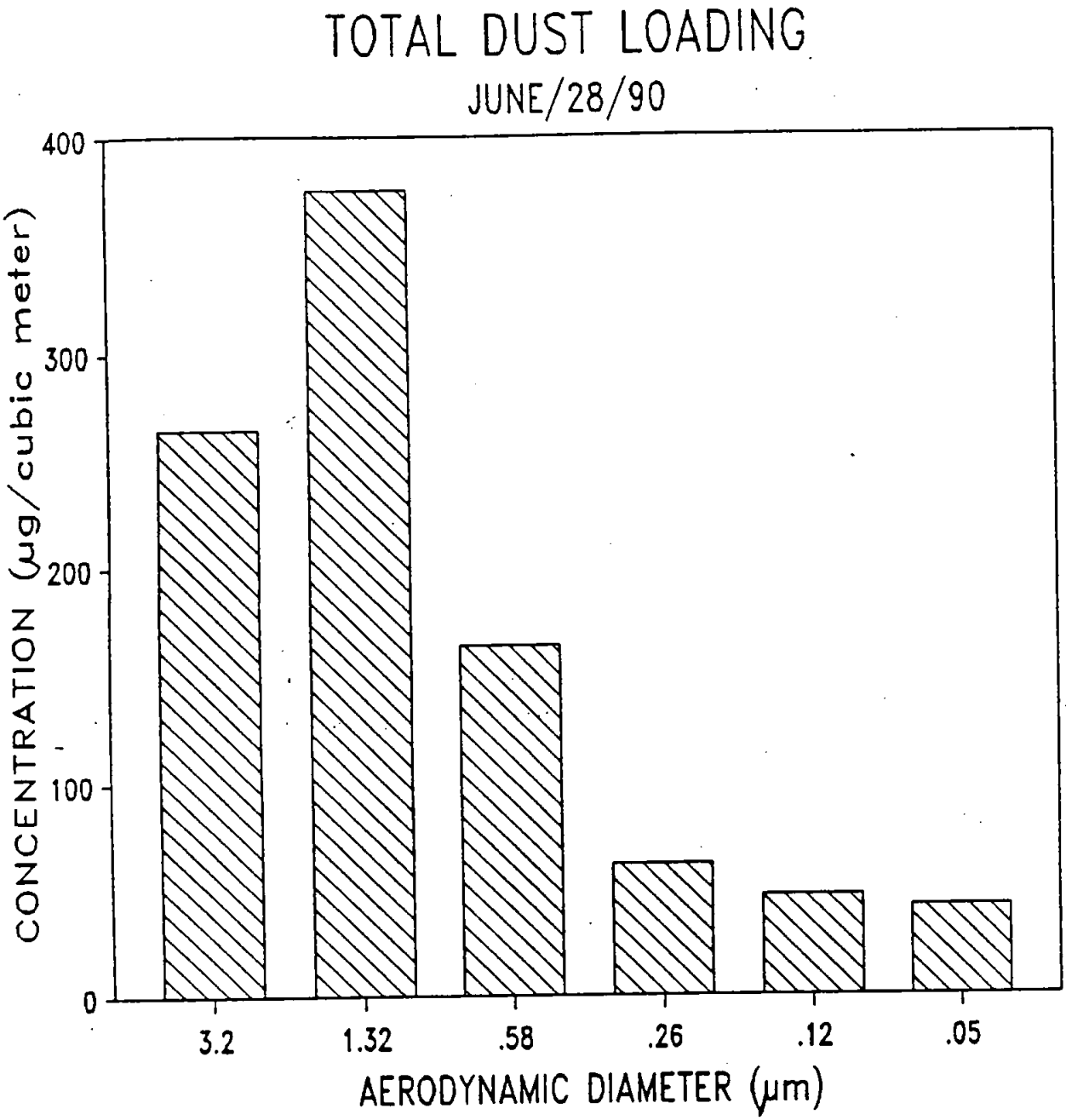

Figure 2: Total dust size distribution for June 28, 1990 at all sampling sites

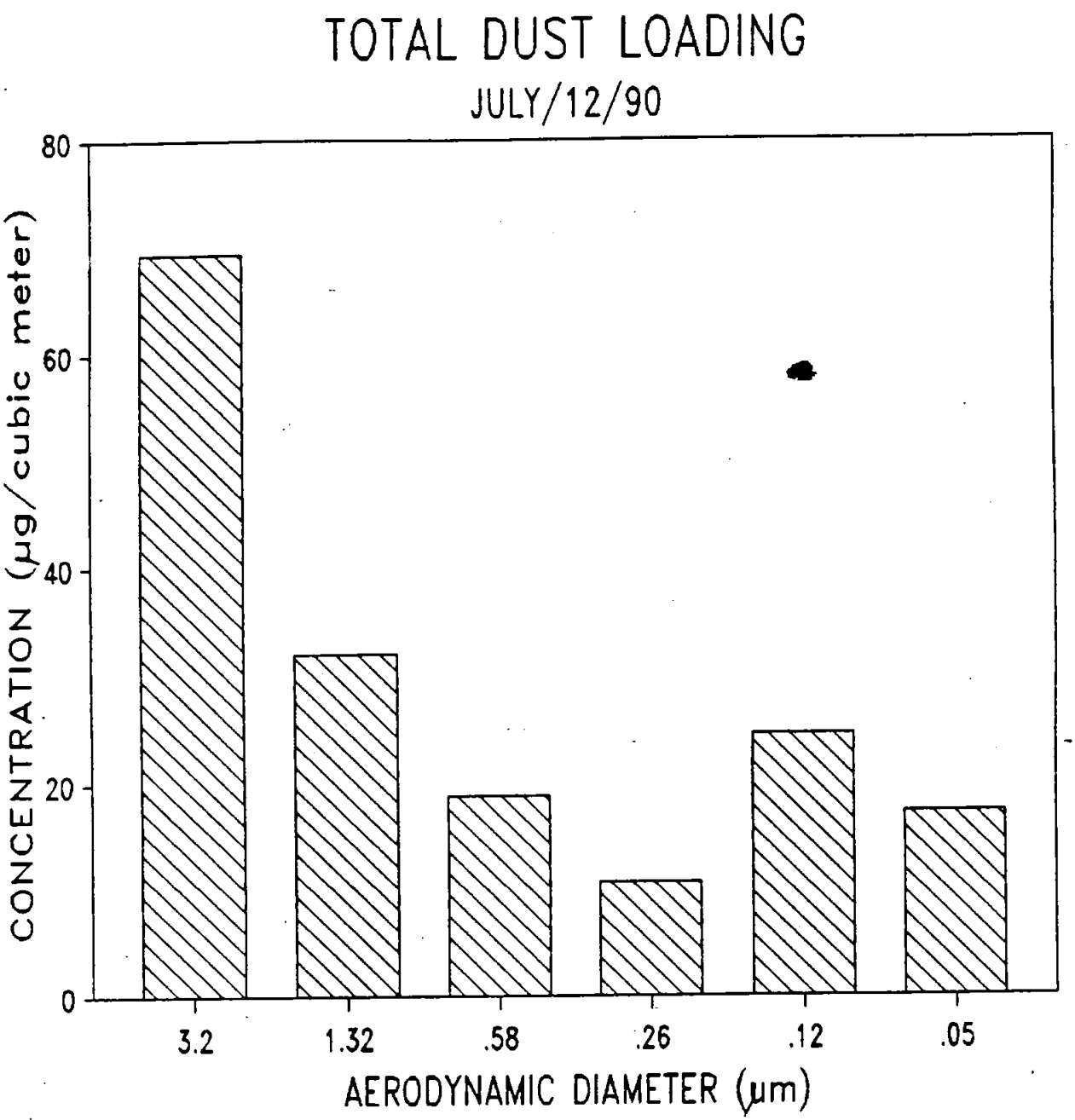

Figure 3: Total dust size distribution for July 12, 1990 at all sampling sites.

were made with a quartz crystal microbalance cascade impactor (California Measurements Model PC-4). Results for each sampling location, sampling date and impactor stage, are listed in Tables 3, 4 and 5. Sampling times for mine air (0.24 L/min flow rate) varied with dust loadings found - in general 1 to 5 minute samples were taken. The D50 value for each stage represents the diameter at which 50% of the particles are retained on the listed stage. The factor R represents the ratio of the total dust load / cubic m of air at the sampling location, for June 28 (normal mine operations) compared to levels on July 12 (during the summer shutdown). Figures 2 and 3 summarize total dust loading distributions for all measurements made on June 28 and July 12 respectively.

3. DISCUSSION AND CONCLUSIONS

Radon and radon decay product levels on the 6800 ft level are typical of a well-ventilated non-uranium mine, with small uranium/thorium contents in nearby rock. A comparison with previous measurements (1) made in 1988, shows that radon decay products are identical (near 0.006 W.L.) but radon levels in this survey are about 3 times higher (3.3 pCi/L). Little variation with mine operating conditions was evident.

Dust size distributions and levels varied significantly from one site to another - in general, the ore pass area(3) where air flow was clearly at a greater rate, showed a larger proportion of larger dust particles relative to other sites. Dust levels during the shutdown period were reduced to about 1/3 of normal operating values. Total loadings and size distributions compare well with previous measurements, where typically 0.6 to 0.7 mg/cubic m dust loads were found.

REFERENCES

1. E.D. Hallman, H. Lee and E.D. Earle, Sudbury Neutrino Observatory Site - Radon and Dust Assessment, SNO Report SNO-STR-88, September 1988.