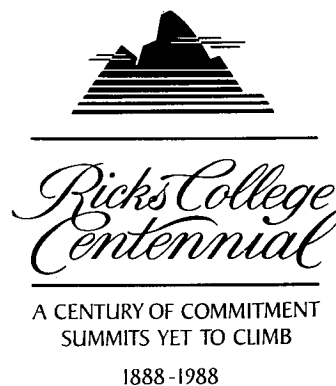


26 August 1988



Ms Shelley Sparhawk
Craters of the Moon National Monument
Arco, Idaho



Dear Shelley:

Enclosed is a list of the specimens I have prepared for your herbarium; A summary of all the lichens I have identified so far with a notation as to where each was found; Results of the electrolyte leakage measurements I made on the two species which I collected for that purpose; and Results of fluoride analysis of timber pine needles performed (free of charge) by Dr. Gene Miller of Utah State University. Under separate cover I am sending the 22 specimens I collected for your herbarium. Remaining to be completed is the SEM-EDAX analysis of heavy metals accumulated by lichens collected at various locations relative to the campground area, which I assume is the main source of atmospheric pollution at Craters.

I have prepared the lichen specimens according to the world wide convention used almost exclusively in the curating of lichens and bryophytes. A few herbaria use a different method, but nearly all herbaria mount lichen (and moss and liverwort) specimens on 9 x 13.5 cm cards placed in 10 x 14 cm envelopes (folded as in these specimens) and stored in filing cabinets with 12.5 x 16 cm drawers. Lichens (like mosses and liverworts) are seldom bothered by insects or fungi in storage, so no special precautions are needed, in curating, for pest control. I have also typed up a couple of rough draft labels and included a blank label from our herbarium hoping these may be of help to you.

Dr. James Allen, who has been doing our EDAX analyses at the INEL, will be back on campus at BYU September 1. He will get to our material as soon as he can. Since I am a member of the BYU faculty, as adjunct professor of botany, the work will be done at campus rate which is very reasonable. I also prepared a couple of specimens for TEM examination. I needed a couple more specimens to round out a batch I was doing for the INEL, so the only expense will be for the pictures since BYU charges by the batch, not by the sample.

I think the results so far have been very interesting. This is the first time electrolyte leakage has been conducted on Letharia columbiana and it appears to be an essentially perfect species for this work. I will be looking forward to the rest of the results.

Sincerely,

Laurie

Lorentz Pearson

10. On rock in limber pine dominated area 150 m north of Cave Parking area in association with other crustose and umbilicate lichens. SW $\frac{1}{4}$ NW $\frac{1}{4}$ S6, T1N, R25E, elev 5,740' (Map location #6)
11. On vertical, north-facing side of basalt formation 25 m north of entrance to Beauty Cave in association with other crustose and umbilicate lichens. NW $\frac{1}{4}$ SE $\frac{1}{4}$ S6, T1N, R25E, elev 5,740' (Map location #8)
12. On massive basalt formation along Wilderness Trail just inside wilderness area in association with Acarospora schleicheri and other crustose lichens. NW $\frac{1}{4}$ NW $\frac{1}{4}$ S18, T1N, R25E, elev 5,840 (Map location #11)
13. Lecanora chrysoleuca (Sm.) Ach. Growing on igneous rocks (?) on cliffs above Research Campground area in association with L. melanophthalma, Acarospora schleicheri, Umbilicaria spp., and other crustose and umbilicate lichens. NE $\frac{1}{4}$, NE $\frac{1}{4}$ S28, T2N, R24E, elev 6,520' (Map location #1)
14. Umbilicaria kraschennikovii (Sav.) Zahlbr. Growing on igneous (?) rock on cliffs above Research Campground area in association with other umbilicate and crustose lichens. NE $\frac{1}{4}$, NE $\frac{1}{4}$, S28, T2N, R24E, elev 6,520' (Map location #1)
15. Acarospora fuscata (Schrader.) Arn.
same information as #13 and 14
No. 16 through 17 collected on same cliffs as No. 7 and 13 through 15
16. Acarospora schleicheri (Ach.) Mass.
17. Candelariella vitellina (Ehrh. Mull.) Arg.
18. Candelariella reflexa (Nyl.) Lett.
Collected on older branch of limber pine across road from Tourist Campground area in association with Parmelia elegantula and P. exasperatula.
SE $\frac{1}{4}$, NE $\frac{1}{4}$ S35, T2N, R24E, elev 5,840' (Map location #2)
19. Parmelia elegantula (Zahlbr.) Szat. Very abundant on limber pine; collected on tree across park road from Tourist campground; associated with Letharia columbiana in very small quantity at this location. SE $\frac{1}{4}$, NE $\frac{1}{4}$, S35; T2N, R24E, elev. 5,860' (Map location #2)
20. Parmelia exasperatula Nyl. Collected on limber pine branch, 100 m north of Cave parking area, in association with abundant Letharia columbiana and other corticolous, mostly foliose lichens. SW $\frac{1}{4}$ NW $\frac{1}{4}$ S6, T1N, R25E, elev 5,740' (Map location #6)

LICHENS OF CRATERS OF THE MOON
NATIONAL MONUMENT

Collected July 5 and 6, 1988 at Craters of the Moon National Monument by Lorentz C. Pearson; identified by Lorentz C. Pearson. See accompanying map for additional detail on collection sites.

1-6: Letharia columbiana (Nutt.)Thoms.

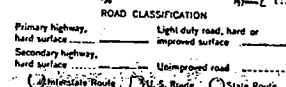
1. On limber pine across main park road from Tourist Campground. SE $\frac{1}{4}$ of NE $\frac{1}{4}$ of Section 35, Township 1 north, Range 24 east; elevation 5,840 feet.
(Map location no. 2)
2. On healthy limber pine near park road between Paisley Cone and Big Craters SW $\frac{1}{4}$, NW $\frac{1}{4}$, S1, T1N, R24E, elev 5,940' (Map location #4)
3. On mistletoe infested limber pine near park road between Paisley Cone and Big Craters SW $\frac{1}{4}$, NW $\frac{1}{4}$, S1, T1N, R24E, elev 5,940' (Map location #5)
4. On limber pine 100 m north of Cave Parking area, SW $\frac{1}{4}$, NW $\frac{1}{4}$, S6 T1N, R25E, 5,740' (Map location #7)
5. On ground under a healthy, lichen-clad limber pine, south of Broken Top Crater near boundary to wilderness area and along Wilderness Trail. SE $\frac{1}{4}$ SE $\frac{1}{4}$ S12, T1N, R24E, elev 5,850' (Map location #9)
6. On limber pine, north slope of Echo Crater. NW $\frac{1}{4}$ NW $\frac{1}{4}$ S29 / SW $\frac{1}{4}$ SW $\frac{1}{4}$ S20, T1N, R25E, elev 5,700'

7-12: Lecanora melanophthalma (Ram.)Ram.

(This species is also known as Rhizoplaca melanophthalma (Ram.)Leuck. Because the Rhizoplacas differ from the Lecanoras only in that they are peltate instead of crustose, and because *L. melanophthalma* is highly variable in form having crustose, peltate, and vagrant forms depending at least partly on environmental factors, I prefer calling it *Lecanora*)

7. Growing on igneous (?) rock on cliffs above research campground area in association with other crustose and peltate lichens. NE $\frac{1}{4}$ NE $\frac{1}{4}$ S28, T2N, R24E, elev. 6,520' (Map location #1)
8. Growing on rocky outcroppings in sagebrush dominated area 75 m south of cliffs above research campground area. Other crustose Lecanoras were common associates. NE $\frac{1}{4}$ NE $\frac{1}{4}$ S28, T2N, R24E, elev. 6,480' (Map location #1)
9. Growing on basalt in tourist campground area in association with L. muralis and Caloplaca saxicola and other depauperate lichens. SE $\frac{1}{4}$ NE $\frac{1}{4}$ S35, T2N, R24E, elev 5,840' (Map location #2)

21. Parmelia subolivacea Nyl. Collected on limber pine, 50 m north of Cave parking area, in association with Letharia columbiana and other lichens. SW $\frac{1}{4}$ of NW $\frac{1}{4}$, Sect. 6, T1N, R25E, elev 5,740' (Map location #6)
22. Lecidea rufonigra (Tuck.) Nyl. Collected on north side of massive basalt formation, 60 m. north of entrance to Surprise Cave in association with other crustose and umbilicate lichens. SE $\frac{1}{4}$ NW $\frac{1}{4}$ Sect. 6, T1N, R25E, elev 5,840' (Map location #7)



LICHENS OF CRATERS OF THE MOON NATIONAL MONUMENT

Lichens were collected at the 16 sites indicated on the accompanying map (with sub-sites, a total of 20 locations). The following have been identified

Site 1, sub-site a, the cliffs above the Research Camp Area where I stayed July 5th and 6th, 1988: Lecanora melanophthalma (Ram.) Ram., Lecanora chrysoleuca (Sm.) Ach., Umbilicaria kraschennikovii (Sav.) Zahlbr., Acarospora fuscata (Schrad.) Arn., Physcia dubia (Hoffm.) Lett., Acarospora schleicheri (Ach.) Mass., and Candelariella vitellina (Ehrh. Mull.) Arg.

Sub-site b, rocks below the cliffs: Lecanora melanophthalma, Lecanora chrysoleuca, Lecanora muralis were all observed.

Site 2, sub-site a, limber pines across park road from campground entrance: Parmelia elegantula was relatively abundant; there was a small amount of Letharia columbiana; also some other corticolous lichens which I have not yet examined carefully.

Sub-site b, rocks in campground area: mostly depauperate specimens of Lecanora and Caloplaca. Lecanora melanophthalma was collected and identified.

Site 6, sub-site a, limber pines north of Cave parking area: Letharia columbiana and Parmelia exasperatula Nyl. were abundant; Parmelia subolivacea was present on the limber pine twigs and branches and also growing on the basal parts of the Letharia. An immature specimen of Candelariella reflexa was tentatively identified.

Sub-site b, basalt in the vicinity of sub-site a was covered with lichens; the following were identified: Lecanora novomexicana (B. de Lesd.) B. de Lesd. non Magn., Lecanora garovaglii (Korb.) Zahlbr., Lecanora melanophthalma, Physcia subtilis Degel., Lecidea globifera Ach., and Candelariella vitellina (Ehrh. Mull.) Arg. Also a strongly uv+ species of Lecanora was relatively abundant; Lecanora atra, tent ID.

Site 3, on trail to North Crater, on limber pine on slope overlooking campground: Crocynia membranacea (Dicks.) Zahlbr., better known under its conserved name, Lepraria membranacea (Dicks.) Lett., growing at the base of the tree; Candelaria concolor Mass., on twigs, and Candelariella reflexa (Nyl.) Lett., very immature, hence identification tentative only.

Site 7, north of Surprise Cave on massive basalt formation: Two species that I have only looked at briefly and tentatively identify as Lecidea russellii Tuck. and Lecidea tessellata (Sm.) Falk.; also Lecanora alphoplaca (Wahlenb. ex Ach.) Ach., cortex K+red, Lecidea macrocarpa (DC.) Steud., and Umbilicaria kraschennikovii (Sw.) Zahlbr. were all present. Also Lecidea rufonigra (Tuck.) Nyl.

Site 11, big rock formation along Wilderness Trail just inside wilderness boundary. Probably 20 or more species of lichens on this rock; the following were identified:

Xanthoria elegans (Link)Th.Fr., Umbilicaria kraschennikovii, Lecanora garovaglii (Korb.)Zahlbr., Acarospora chlorophana (Wahlenb. ex Ach.)Mass., Caloplaca lamprocheila (D.C. in Lam.&D.C.)Flag.

SUMMARY OF SPECIES IDENTIFIED TO DATE (Aug 1988)

Only six of the 16 sites have been carefully examined; even these have not been examined in great detail. Some species--like the bright chartreuse Letharias and Acarosporas and the deep orange Caloplacas and Xanthorias--are readily observed; others, like the gray and brown crustose species on trees and shrubs, are easily overlooked. These are the species I have identified so far during the limited time I had available. The numbers refer to which of the six map locations I observed each species. Exception: Lecanora melanophthalma was found at 6 of the 16 locations and Letharia columbiana at 9 of the 16, but all other species in the list were only found at a maximum of six map sites.

<u>Acarospora chlorophana</u> (Wahlenb. ex Ach.)Mass.	#11	
<u>Acarospora fuscata</u> (Schrad.)Arn.	#1	
<u>Acarospora schleicheri</u> (Ach.)Mass.	#1	
<u>Caloplaca lamprocheila</u> (D.C. in Lam.&D.C.)Flag.	#11	
<u>Caloplaca saxicola</u> (Hoffm.)Nordin	#2	
<u>Candelaria concolor</u> Mass.	#3	
<u>Candelariella reflexa</u> (Nyl.)Lett.	#2,6	tentative ID
<u>Candelariella vitellina</u> (Ehrh.Mull.)Arg.	#1,6	
<u>Lecanora alphoplaca</u> (Wahlenb. ex Ach.)Ach.	#7	
<u>Lecanora atra</u> (Huds.)Ach.	#6	(tentative ID)
<u>Lecanora chrysoleuca</u> (Sm.)Ach.	#1	
<u>Lecanora garovaglii</u> (Korb.)Zahlbr.	#6, 11	
<u>Lecanora melanophthalma</u> (Ram.)Ram.	#1, 2, 3, 6, 8, 11	
<u>Lecanora muralis</u> (Schreb.)Rabenh.	#1, 2	
<u>Lecanora novomexicana</u> (B.de Lesd.)B.de Lesd. non Magn.	#6	
<u>Lecanora</u> sp. strongly UV+	#6	
<u>Lecidea globifera</u> Ach.	#6	
<u>Lecidea rufonigra</u> (Tuck.)Nyl.	#7	
<u>Lecidea russellii</u> Tuck.	#7	
<u>Lepraria membranacea</u> (Dicks.)Lett.	#2	
<u>Letharia columbiana</u> (Nutt.)Thoms.	#2, 4, 5, 6, 9, 10, 14, 15, 16	

<u>Parmelia elegantula</u> (Zahlbr.)Szat.	#2	
<u>Parmelia exasperatula</u> Nyl.	#6	
<u>Parmelia subolivacea</u> Nyl.	#6	
<u>Physcia dubia</u> (Hoffm.)Lett.	#1	Tentative ID
<u>Physcia subtilis</u> Degel.	#6	Tentative ID
<u>Umbilicaria krascheninnikovii</u> (Sw.)Zahlbr.	#1, 7, 11	
<u>Xanthoria elegans</u> (Link)Th.Fr.	#11	

RESULTS OF ELECTROLYTE LEAKAGE TEST

A simple measure of the condition of lichen membranes can be made with the Pearson (1985) electrolyte leakage test. When healthy lichens are immersed in distilled water, the conductivity of the water increases only slightly. When lichens which have been exposed to gaseous pollutants, such as sulfur dioxide, which damage the cell membranes, the conductivity of the water increases considerably. If the pollution has killed the lichens or very much of the lichen tissue, the conductivity increase is relatively slight, as a rule.

Lichens were collected from the tourist campground area and several other locations, placed in a humidity chamber for three or four hours, and then immersed in distilled water. The results are indicated in the tables below.

TABLE 1. Comparisons among the nine collections of *Letharia columbiana* for evidence of membrane damage as revealed by conductivity of water in which specimens were immersed. Average conductivity increase in micromhos per gram for each ml water ($\mu\text{S/g/ml}$). Number in parentheses after each site description indicates the number of specimens collected and tested at that site.

MAP LOCATION	DESCRIPTION		AVG INCREASE IN CONDUCTIVITY *	
2	Tourist campground	(1)	7,642	BC
4	Paisley Crater -- Healthy tree	(1)	12,851	A
5	Paisley Crater -- Mistletoe infested tree	(5)	9,494	B
6	Cave Parking area	(4)	5,034	C
9	Broken Top -- on tree	(9)	5,553	C
10	Broken Top -- on ground	(6)	5,418	C
14	End of Trail	(6)	6,402	C
15	Crescent Butte	(4)	6,312	C
16	Echo Crater	(8)	5,690	C

*Statistical significance at $P=0.05$ indicated by different letters of the alphabet following the conductivity value; two values followed by the same letter are statistically not significantly different from each other

TABLE 2. Same data as in Table 1 but pooled for areas close to each other in order to avoid values based on only one specimen. Values and statistical significance as in Table 1.

GROUP	SITES INCLUDED	DESCRIPTION	NO OF SPECIMENS (n)	AVG INCREASE IN CONDUCTIVITY
A	2,4,5	Areas with heavy traffic	7	9,709 A
B	6	Moderate traffic within 150 m	4	5,034 B
C	9,10	Light traffic within 1000 m	15	5,471 B
D	14,15,16	Wilderness area -- no traffic	18	6,066 B

Analysis of variance of the Lecanora melanophthalma electrolyte leakage did not reveal any statistically significant differences. The average leakage values are shown in Table 3. Leakage appeared to be greater in the campground and North Crater areas, but variation within locations was relatively high.

TABLE 3. Comparison among the nine collections of Lecanora melanophthalma for evidence of membrane damage. Average conductivity increases and statistical significance indicated as in Tables 1 and 2.

MAP LOCATION	SITE DESCRIPTION	n	AVERAGE INCREASE IN CONDUCTIVITY INDIVIDUAL SITES	GROUP AVERAGES
2	Tourist campground	2	417	
3	North Crater Trail, near campground	2	569	
	Group A: nearest source	4		493
6a	50 m north of Cave Parking Area	3	467	
6b	100 m north of Cave Parking Area	1	131	
6c	150 m north of Cave Parking Area	2	313	
	Group B: morning downwind	6		360
8	50 m north of Beauty Cave	1	381	
11	On border to Wilderness Area	9	375	
	Group C: distant downwind	10		376
1a	On cliffs above research camp area	3	223	
1b	Rocks below cliffs	4	373	
	Group D: upwind from source	7		308

Previous studies (Rope and Pearson, unpublished INEL data) have indicated that lichens on the morning downwind side of a source of pollution are damaged more by pollution than those on the daytime downwind side of the source even though more total pollution may be emitted during the daytime or the wind may blow more frequently in the daytime. If we assign a subjective value to each site in Table 3 assuming that site 1a would have the least pollution and 2 would have the most, we can calculate correlation coefficients for the conductivity values as related to the site values. For the individual sites, $r = 0.46$ and for the groups, $r = 0.891$. While this latter value looks impressive, neither correlation coefficient is statistically significant.

Next to lichens, the white pine group of conifers are probably the most sensitive plants to most air pollutants. Mistletoe infested limber pine at some locations in the Park show classical symptoms of fluoride injury. Inasmuch as other things--pathogenic organisms, for example, or other pollutants--can cause symptoms similar to those usually associated with a particular causal agent, I sent four specimens of ~~limber~~ pine to Prof. Gene Miller at Utah State University, recognized by his colleagues as the leading authority on fluoride injury to plants in the United States. Dr. Miller's response is enclosed. I asked him if the symptoms could be due to mistletoe injury, inasmuch as they seemed to be associated with the mistletoe. He said it is possible, but did not elaborate further. I would guess that the slightly elevated fluoride content in the pine needles collected near the campground could have been caused from a variety of things tourists bring with them ranging from hair spray in aerosol containers to refrigeration units and air conditioning in their automobiles. I sent a few leaves from the tree across the road from the campground, but the material was so slight that he could no run an analysis on it.

We have prepared specimens from four or five of the areas for scanning electron microscope and energy dispersal analysis of x-ray examination. This will be performed some time in September. As soon as completed, the results will be sent to you.

ANALYSIS OF VARIANCE, CRATERS OF THE MOON ELECTROLYTE LEAKAGE DATA

LECANORA MELANOPHTHALMA

	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>
Among sites	8	240,846	30,106	NS
Among Areas	3	87,888	29,296	NS
Residual	5	152,957	30,591	
Within Sites (Error)	18	499,338	27,741	
TOTAL	26	740,184		

LETHARIA COLUMBIANA

	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>
Among Sites	8	115,513	14,479	6.477**
Among Areas	3	(98,887)	32,962	(9.912)**
Residual	5	(16,626)	3,325	
Within Sites (Error)	35	78,237	2,235	
TOTAL	43	193,750		

*Significant at $P = 0.05$

** Significant at $P = 0.01$



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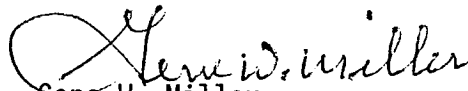
August 8, 1988

Dr. Lorentz C. Pearson
Department of Biology
Ricks College
Rexburg, ID 83440

Dear Dr. Pearson:

Enclosed are the fluoride analyses for the Crater of the Moon National Monument. There was not enough sample sent to determine sample #2. The values found are only slightly above the normal range in Fluoride, which probably does not account for the burning.

Sincerely,


Gene W. Miller
Professor of Biology

GWM/klh

Enclosure

Fluoride content in samples from the Craters of the Moon National Monument
(collected 5 and 6 July 1988).

# of sample	site	ppm of F
1	campingground area (trail to North Crater)	17
2	— " —	*
3	southwest slope of Crescent Butte	14
4	northeast slope of Echo Butte	14

* the sample was definitely too small to make analyses.