

## SUMMARY OF 1988 CRATERS OF THE MOON LICHEN STUDY

BY L. C. PEARSON, RICKS COLLEGE

Lichens were collected July 5 and 6, 1988, at Craters of the Moon National Monument and identified in July and August 1988. A report was sent to Shelley Sparhawk 26 August 1988. The following is a summary of that report and of developments since that date.

1) Lichens were collected at 16 sites identified on a map sent to Ms Sparhawk (with subsites, a total of 20 locations). There are a number of species which have not yet been identified plus some which have been tentatively identified but will need to be confirmed by lichen specialists. Twenty-three species have been identified and verification specimens of twelve of these have been sent to Ms Sparhawk.

2) Including the above, 22 herbarium specimens have been prepared and sent to the Craters of the Moon Herbarium for inclusion in their lichen collection. Six voucher specimens each of Letharia columbiana and Lecanora melanophthalma were included.

3) Electrolyte leakage was measured on 44 specimens of Letharia columbiana collected at nine locations, and 27 specimens of Lecanora melanophthalma collected at nine locations--for a total of 71 specimens collected at sixteen of the twenty locations. Leakage was significantly higher ( $P < 0.01$ ) in Letharia collected at the Tourist Camping Area and near a parking area on the main park road approximately a mile south of the Tourist Camping Area than in the lichens collected in the Caves Area and in the Wilderness Area. The same pattern characterized the leakage from thalli of Lecanora melanophthalma but the differences among locations at which Lecanora was collected were not statistically significant.

4) The first specimens tested by scanning electron microscopy (SEM) and energy dispersal analysis of X-rays (EDAX) did not indicate any heavy metal pollution in the Monument. Only one specimen of five requested has been tested at this time, however, so it is too early to have much confidence in these results.

5) Transmission electron microscope (TEM) images have not shown any abnormalities in any of the lichens collected at Craters as far as the EM technicians in Provo could tell. I will examine the material on Saturday, October 2nd, and identify the areas that should be photographed. Copies of the photographs will be sent to Craters of the Moon at that time.

6) Most of the corticolous lichens were collected on Pinus flexilis stems. At some locations mistletoe had heavily infested the trees. Needles on some of the mistletoe infected trees showed classical fluoride toxicity symptoms. Specimens of Pinus

needles were sent to Dr. Gene Miller at Utah State University for chemical analysis. Fluoride levels were not high enough in the needles to account for fluoride injury in these trees; therefore, the symptoms probably have resulted from some other type of injury, possibly the mistletoe, or possibly something else.

7) Several factors indicate that Letharia columbiana is an excellent species for monitoring of atmospheric pollution: (a) It is an abundant species at Craters of the Moon; (b) Electrolyte leakage indicates it is a very sensitive species to some atmospheric pollutants; (c) Its absence from areas immediately downwind--in the primary nighttime downwind direction--from the probable major source of pollution in the Monument, the Tourist Campground, also indicates that it is a very sensitive species and has not been able to survive there even though suitable substrate is present; (d) Because of its abundance, it can be harvested in the large amounts needed for some kinds of analyses; (e) It is pliable and easy to section for both SEM and TEM examination; and (f) Substrate material, that can be a nuisance when working with a lichen and can even damage microtome blades, is easily removed from the specimens.

8) A map showing where the lichens were collected and a description of each collection site were sent with the previous report. Average electrolyte leakage, of both Letharia columbiana and Lecanora melanophthalma, was shown in Tables 1-3 in the previous report, and analyses of variance were shown in Table 4.

9) It is recommended that in 1989: (a) Collecting of lichens for inclusion in the herbarium be continued with collecting extending to the north boundary of the Monument along the cliffs in the Pioneer Mountains and farther south in the Buttes in the Wilderness Area. Also that collecting be done on and in the Buttes in the Wilderness Area. (b) That difficult to identify specimens be sent to specialists and that voucher specimens of every species sent to specialists, as well as those identified locally, be included in the Monument Herbarium. (c) That specimens of Letharia columbiana, Lecanora melanophthalma, Parmelia exasperatula, and possibly other pollution sensitive lichens be collected along the eastern border of the Monument, where pollution is most likely to exist, and examined by SEM-EDAX, probably by INEL in Idaho Falls with their new equipment, to monitor any possible accumulation of heavy metals carried by the nighttime winds from the INEL desert site. (d) That work begin on a quality display that will help visitors to Craters of the Moon appreciate this unique resource which is so well developed here. There is such a wealth of lichens here that Craters ought to be the outstanding National Park unit for the display of this resource.

Specimens mounted for  
Craters Herbarium

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)

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 (Schröd.)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.Müll.)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)

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:

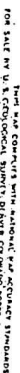
Xanthoria elegans (Link)Th.Fr., Umbilicaria kraschennikovii, Lecanora garovaglii (Korb.)Zahlbr., Acarospora chlorophana (Wahlenb. ex Ach.)Mass., Caloplaca lamprocheila (D.C. in Lam.&D.C.)Flag.

#### 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       |              |



INFERNO CONTE, IDAMHO

## 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<br>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 not 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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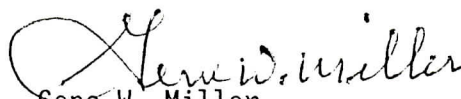
August 8, 1988

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

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.