A Review: The Lichen Role in Rock Art — Dating, Deterioration and Control

M.L.E. Florian

Introduction

Rock surfaces at many rock art sites around the world support encrusting growths of lichen. These primitive plants are a complex of fungi and algae which live together in a symbiotic relationship for mutual benefit. The saprophytic fungi supply the support, water and minerals while the photosynthetic algae supply the organic material. The encrusting growth of lichen may mask or aesthetically destroy the rock art.

In the past the removal of lichen from rock art surfaces has been mainly to reveal the art. There has been little thought as to the complex role of lichen such as its potential use in dating, whether or not lichen removal prevents or enhances rock surface deterioration and the effectiveness of and potential deterioration caused by control methods.

The purpose of this paper is not only to review the role of lichen in rock art but hopefully to gather together comments on your observations or research which will give a better understanding to this role. There are three areas I would like to discuss:

i) The use of lichen community analysis in *dating* exposure time of the substrate;
ii) The questions of whether or not lichens cause *deterioration* to their substrate and if lichen removal will enhance deterioration of an already deteriorated substrate; and
iii) *Control*, methods of lichen removal and inhibition.

Dating

The use of lichen community analysis could assist in dating rock art in some cases. Community analysis includes thallus size, percent lichen coverage, species composition, thallus size frequency and succession stage. Thallus size along with growth rates in time have been used to determine the age of lichen substrates. This method of substrate dating called lichenometry was developed by Beschel[1]. Methods of measurement and calculation of growth rates are given by Beschel[1], Hale[2] and Smith[3]. From the literature, it appears that lichenometry alone may have a limited role, if any, in dating rock art. Vol. 5, No. 4 1973 of Artic and Alpine Research was dedicated to the late Roland Beschel. In the commentary[4] of this memorial issue, the problems of the use of lichenometry are outlined and it is pointed out that the biological and ecological foundation of lichenometry are so tenuous as to almost preclude it use. Glacial geologists are the principal users but even Birkeland[5, 6], an outstanding glacial geologist, suggests it should be only one of the dating tools. Selwyn Dewdney[7] in his book "Dating Rock Art in the Canadian Shield Region" tried to use lichenometry under the supervision of Beschel to assist his dating project. He was aware of its limitations and pointed out that the environment of surfaces of petrography may not give optimal growth rate and that it is difficult to give time values to such things as early establishment of algae and fungi spores, the precursors to the lichen symbiot. The Easter Island megaliths have been given a time of construction of 430 years ago using lichenometry[8]. This is considerably younger than was expected and may be erroneous due to the limitations of this dating method. McGhee[9] used lichenometry to assist in dating petroglyphs of possible Medieval Irish origin in Newfoundland. The boulder on which the petroglyph or inscription was carved was covered with a heavy encrustation of lichen. A small area over the inscription was, at some time, cleaned of lichen. In this cleaned area new lichen growth was estimated by lichenometry to be 150-200 years old. The date of the petroglyphs was not obtained but it was shown that it was not a recent archaeological forgery.

Birkland[5, 6] as mentioned before, pointed out that lichenometry is only one dating tool, he used as well, degree of *lichen cover* as a criterion for relative age dating of Neoglacial morains.

Benedict[10] has also documented variations in the percentage of lichen covered areas as functions of substrate age. Benedict[11] states that in addition to lichen cover, *species composition*, which is relative proportions of individual species present, can be helpful. *Size frequency diagrams* to distinguish between lichen population of different ages have been used by Benedict[11] to date an Indian wall constructed of partly colonized stones.

Ecological *successions* (the orderly progression of ecological communities through time), for example species diversity, structural complexity, biomass and stability tend to increase with successional age of an ecosystem. Shugart and Hett[12] show how successional rates can be mathematically described. With lichen populations which have a slow succession rate it seems possible that substrate dating could be assisted by this method[6]. Lichen successions do occur. Beschel[13] describes epipetric lichen succession in the Eastern Nearctic. Hale[14, 15] describes lichen growth rate and succession at a rock station in the Aton Forest, Connecticut, over a period of five years. Robinson[16] observed different lichen successions on fields abandoned for different times up to 40 years and was able to date last time of cultivation of the fields by this information.

Thus, the literature suggests that an analysis of the lichen communities including: thallus diameter; lichen coverage; species composition; size frequency and stage in succession, may assist in dating exposure of rock art substrates. Mind you, the substrate exposure age may only indicate the last time that Professor Anati removed the lichen from Valcamonica or Martin Weaver from Sydney, Australia sites, or John Clarke from the West Australian sites.

Deterioration

The pedogenetic significance of lichens is reviewed by Syers and Iskandar[17]. From the literature there is no doubt that biogeophysical weathering of rock surfaces can be caused by some lichen. Mechanical damage by rhizine penetration and contraction of drying gelatinous hypothalli are two examples. Syers and Iskandar[17] state that the rhizine of endolithic species can penetrate and pit the surface of limestone up to 16 mm deep. Richardson[8] and Fry[18, 19] describe the role of contraction of drying gelatinous hypothallus in mechanically fracturing rock and glass surfaces. Lal[20] reports that algae films (the precursor to lichen) have caused surface flaking of rock surfaces by this process.

Biogeochemical weathering has been shown to be caused by the chemical deterioration of substrates by end products of lichen metabolism. Biogeochemical weathering due to epilithic lichen on lava[21] is attributed to the action of respiratory CO_2, H^+ ions of organic acids and organic complexing agents. These complexing agents have a chelating effect. The agents form water soluble metal complexes with insoluble rock materials[17, 22, 23].

Lichens have been shown to accumulate elements, (Ca, Cu, Fe, Mg, Zn) from their substrate in abnormally large amounts. In the review on substrate ecology of lichens, Brodo[24] reports that the amount accumulated may or may not reflect the amount in the substrate. In one example in which it did, Lounamaa[25] compared the amounts of iron, magnesium and zinc in epilithic lichen and showed that the amounts reflected the amounts in the substrate. This could possibly be used as a method of determining regions of pigment loss on rock art by accumulation in lichen.

Even though it is apparent that lichens cause physical and chemical damage, it is necessary to determine by research if removal of such lichen will enhance the physical weathering of an already deteriorated area. This also applies to lichen removal for an aesthetic purpose or to assist in clarity of design for recording.

Control

Methods of lichen removal have been offered in the literature, but with no supportive research as to their effect on the substrate or length of effectiveness with time. Most of the methods are devised for removal from buildings. Schaffer[26] suggests for natural stone buildings, lichen can be removed by silico fluoride wash. It is mentioned that this treatment may form a hard skin surface which may flake off. He also recommends dilute ammonia and gentle brushing. Building Research Station Digests[27 - 29] suggest for building materials, household bleach (hypochlorite) 1-2% orthophenylphenate, 2% sodium pentachlorophenate, 4% zinc or magnesium silico fluoride, 5% formaldehyde, 1 oz. copper carbonate in 10 oz. ammonia. Mechanical removal by brushing, steam cleaning and sand blasting have also been suggested for lichen removal. Lal[20] reported on the use of thymol to control lichen. Sneyers and Henan[30] recommend, for removal of lichen from stonework, the use of soft brushing after dilute ammonium wetting. A nitrocellulose plastic stripping film was suggested to remove stubborn thin algae surface films.

In India, on stone monuments, Gairola[31] suggests the removal of lichen by 3-5% ammonia and gentle brushing, and the cleaned surface treated with 1-2% aqueous zinc silico fluoride solution repeated after a week and finally coated with protective vinyl acetate or methyl methacrylate.

It is logical to prevent new lichen growth after cleaning surfaces. Gairola[31] methods do this. Lloyd[32] has tested the following lichen inhibitors:

(LPCP) 1% aqueous emulsion of pentachlorophenyl laurate; (Cu 8) 1% aqueous dispersion of Copper -8 quinolinolate 10% concentrate; (PPI) 1% alc/aqueous dispersion of pentachlorophenol and trichlorophenoxy isopropanol mixture; and (PP5) 5% aqueous solution of PPI/ammonium sulphate. The results were preliminary results, but showed PPI to give best killing power but inhibition properties were not assessed.

There is very little in the literature on lichen removal from rock art. Boustead[33] in New Zealand used 5% ammonia, with a follow-up surface treatment of magnesium silica fluoride or zinc silica fluoride to prevent fresh growth. Martin Weaver (unpublished) has used a nonionic detergent and gentle brushing for removal of lichen on some Sydney sites. Prof. Anati (unpublished) inadvertently has inhibited lichen growth by rubbing some Valcamonica petroglyphs with white casein paint containing phenol.

The treatments or chemicals mentioned above fall into four categories: substrate surface treatment, biocides, lichen swelling agents and mechanical removal. The use of zinc or magnesium silico fluoride has the combined effect of the toxic action of zinc and fluoride on lichen, the fluoride possibly hardening some mineral components of the substrate and the silica coating the surface. It is reported[26] that this treatment may cause exfoliation. The biocides used are fungicides which attack the fungus component of the lichen. The resistance of lichen algae after treatment is not reported. Algae films have been reported[20] to cause exfoliation of rock surfaces. The possible selective role for algae growth by the use of fungicides should be tested. The alkaline solutions swell and soften the lichen thallus enabling its mechanical removal. The possible chemical reaction of these solutions on the substrate should be thoroughly researched before use. Also the swelling of endolithic lichen could possibly encourage substrate fracturing. Copper compounds are toxic to algae and fungi but often cause substrate colour change.

Thus in looking at the suggested chemicals for lichen removal or inhibition it is obvious that there are both pros and cons in respect to their use. Before any chemicals are used on rock art, their reaction on the specific substrate must be determined. Pearson[34] pointed out the danger of using a treatment reported successful on one rock art site on a different site, before prior tests. His example was with a surface consolidant, but the example has application to lichen control methods as well.

Avery[35] and Boustead[33] discuss preservation of rock art by environmental control such as surface protective coatings, drainage, impregnation and removal of rock art itself to Museums. All these will in themselves control or kill lichen growth. Maybe these natural methods of control are the answer.

Summary

1. If dating of lichen covered rock art is necessary, it is possible that information could be gleaned from the analysis of the lichen community.
2. Even though it is apparent that lichens cause physical and chemical damage to their substrate and impair recording and aesthetic appreciation of the rock art, it is important to know if their removal will cause further substrate deterioration.
3. Before any lichen removal methods are used on rock art, their reaction on the substrate and effectiveness as lichen inhibitors or eradicators must be assessed for each specific site.
4. Environmental control of rock art sites should be looked at as a logical method of lichen control.

This is a workshop we are all involved in, thus I hope that these remarks will bring forth some remarks, ideas and comments from your own observations and research which will help to give us a better understanding of these areas of the role of lichen in rock art.

References

1 Beschel, R.E. (1960). Dating Rock Surfaces by Lichen Growth and its Application to Glaciology and Physiography (Lichenometry). *Geology of the Arctic, Proceedings of the First International Symposium on Arctic Geology, Vol. II,* (Ed. G.O. Raasch), Univ. Toronto Press. 1044-1061.

2 Hale, M.E. Jr. (1967). Chp. 6, Growth and Longevity. in: *The Biology of Lichens,* Edward Arnold (Publishers) Ltd., London. 77-83.

3 Smith, D.C. (1962). The Biology of Lichen Thalli. *Biological Review, 37,* 537-570.

4 Webber, P.J. and Andrews, J.T. (1973). Lichenometry: A Commentary. *Arctic and Alpine Research, 5 (4),* 295-302.

5 Birkeland, P.W., (1973). Re-Interpretation of the Type Temple Lake Moraine, and Other Neoglacial Deposits, Southern Wind River Mountains, Wyoming. *Geological Society of America, Abstracts with Programs, 5 (6),* 465-466.

6 Birkeland, P.W. (1973). Use of Relative Age-dating Methods in a Stratigraphic Study of Rock Glacier Deposits, Mt. Sapris, Colorado. *Arctic and Alpine Research, 5 (4),* 401-416.

7 Dewdney, S. (1970). Dating Rock Art in the Canadian Shield Region. *Royal Ontario Museum. Occasional Paper, 24.*

8 Richardson, D.H.S. (1975). Soils, Stonework and Stained Glass. in: *The Vanishing Lichens*, Hafner Press. 66-74.

9 McGhee, R. (1976). Did the Medieval Irish Visit Newfoundland? *Can. Geo. Jour., 92 (3)*, 66-73.

10 Benedict, J.B. (1968). Recent Glacial History of an Alpine Area in the Colorado Front Range, U.S.A. II. Dating the Glacial Deposits. *Journal of Glaciology, 7 (49)*, 77-87.

11 Benedict, J.B. (1967). Recent Glacial History of an Alpine Area in the Colorado Front Range, U.S.A. I. Establishing a Lichen-Growth Curve. *Journal of Glaciology, 6 (48)*, 817-832.

12 Shugart, H.J. and Hett, J.M. (1973). Succession: Similarities of Species Turnover Rates. *Science, 180*, 1379-1381.

13 Beschel, R.E. (1965). Epipetric Succession and Lichen Growth Rates in Eastern Nearctic. *Abstract for the International Quaternary Congress, Denver, Colorado, Group I, Present Day Environment and Processes, Section b, Arctic and Alpine Environment*, 1-3.

14 Hale, M.E. Jr. (1954). First Report on Lichen Growth Rate and Succession at Aton Forest, Connecticut. *The Bryologist, 57*, 244-247.

15 Hale, M.E. Jr. (1959). Studies on Lichen Growth Rate and Succession. *Bull. Torrey Bot. Club, 86 (2)*, 126-129.

16 Robinson, H. (1959). Lichen Succession in Abandoned Fields in the Piedmont of North Carolina. *The Bryologist, 62 (4)*, 254-259.

17 Syers, J.K. and Iskandar I.K. (1973). Pedogenetic Significance of Lichens in: *The Lichens.* Eds. V. Ahmadjian and M.E. Hale. Academic Press. 225-248.

18 Fry, E.J. (1924). A Suggested Explanation of the Mechanical Action of Lithophytic Lichens on Rocks (Shale). *Annals of Botany, 38 (159)*, 175-196.

19 Fry, E.J. (1927). The Mechanical Action of Crustaceous Lichens on Substrata of Shale, Schist, Gneiss, Limestone, and Obsidian. *Annals of Botany, 41 (163)*, 437-460.

20 Lal, B.B. (1970). Indian Rock Paintings and Their Preservation. *Australian Aboriginal Studies No. 22*, 139-146.

21 Jackson, T.A. and Keller, W.D. (1970). A Comparative Study of the Role of Lichens and "Inorganic" Processes in the Chemical Weathering of Recent Hawaiian Lava Flows. *Amer.J.Sci., 269*, 446-466.

22 Iskandar, I.K. and Syers, J.K. (1971). Solubility of Lichen Compounds in Water: Pedogenetic Implications. *Lichenologist, 5*, 45-50.

23 Bobritskaya, M.A. (1950). Absorption of Mineral Elements by Lithophyllic Vegetation on Massive Crystalline Rocks. *Tr. Pochv. Inst., Akad. Nauk SSSR, 34*, 5-27. Russian.

24 Brodo, I.M. (1973). Substrate Ecology. in: *The Lichens* Eds. V. Ahmadjian and M.E. Hal. Academic Press. 401-441.

25 Lounamaa, K.J. (1965). Studies on the Content of Iron Manganese and Zinc in Macrolichens. *Annales Botanici Fennici, 2(2)*, 127-137.

26 Schaffer, R.J. (132). The Weathering of Natural Building Stones. *Dept. Sc. and Ind. Research, Building Research, Special Report, No. 18*, 72-88.

27 Anon. (1950). The Weathering, Preservation and Maintenance of Natural Stone Masonry. (Part II). *Building Research Station Digest, First Series, 21:* 1-8.

28 Anon. (1963). The Control of Lichens Moulds and Similar Growths on Building Materials. *Ibid, 47*, 1-4.

29 Anon. (1972). Control of Lichens, Moulds and Similar Growths. *Ibid, 139*, 1-4.

30 Sneyers, R.V. and Henan, P.J. (1968). The Conservation of Stone. in: *The Conservation of Cultural Property.* UNESCO Rome. 209-235.

31 Gairola, T.R. (1968). Examples of the Preservation of Monuments in India. *Ibid.* UNESCO Rome. 139-152.

32 Lloyd, A.O. (1972). An Approach to the Testing of Lichen Inhibitors. in: *Biodeterioration of Materials*, (Eds. A.H. Walters and E.H. Hueck-van der Plas), Halsted Press Division, John Wiley & Sons, Inc., N.Y. 2, 185-191.

33 Boustead, W.M. (1970). Museum Conservation of Anthropological Material. in: *Aboriginal Antiquities in Australia*, (Ed. F.D. McCarthy), Australian Aboriginal Studies No. 22, 127-134.

34 Pearson, C. (1975). Conservation Needs in the Field. in: *The Preservation of Australia's Aboriginal Heritage* Australian Aboriginal Studies, No. 54, 95-101.

35 Avery, G. (1975). South African Problems and Conditions and the Preservation of Rock Art. in: *Conservation in Archaeology and the Applied Arts;* preprints of the IIC Stockholm Congress, IIC, London. 1-5.