Lichen biodeterioration of Megalithic Heritage of Manipur: An assessment of Risk and Response

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Introduction

Megaliths of Manipur – enduring symbols of culture – face a silent threat: biodeterioration.
Among its agents, lichens play a dual role – protective layer or destructive force?

- How does it happen?
  - Physical penetration of stone
  - Chemical alteration through organic acids
  - Formation of biofilms that trap moisture and pollutants
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- Why it matters?
  - Megalithic monuments of Manipur represent irreplaceable cultural heritage
  - Lichen colonization affects stone stability and aesthetics
  - Conservation choices remain debated – should we remove lichens or sustain their ecosystem role?

Core Question:
Are lichens guardians of Manipur's megalithic heritage or agents of its decay?

Objectives

Tagline: "From Stone to Spore: Understanding the Lichen Impact"

1. **Characterize**
→ Analyze mineral composition of megalithic stones to evaluate susceptibility.

2. **Identify**
→ Document saxicolous lichen species colonizing the monuments.

3. **Assess**
→ Investigate biodeterioration at the lichen–rock interface using advanced imaging and chemical analysis.

4. **Decide**
→ Recommend whether to remove lichens for preservation or sustain them as part of the ecosystem.

Research Methodology

LICHEN IDENTIFICATION

- SPOT TEST, MICROCRYSTALLOGRAPHY
- THIN LAYER CHROMATOGRAPHY (TLC)

Sl. No.	Sample No.	Acc. No.	Spot test	TLC Results	Lichen Species
01	WI-1	36128	K+ P+	Salazinic: Rf -2 Atranorin: Rf -7	*Parmotrema reticulatum* (Taylor) M. Choisy
02	WI-2	36129	K+ yellow P+	Sticitic: Rf-3	*Porpida albocaerulescens* (Wulfen) Hertel & Knoph
03	WII-1	36130	K+ Yellow C+	Atranorin: Rf-7	*Lecidella stigmatea* (Ach.) Hertel & Leuckert
04	WII-2	36131	K+ Yellow C+	Atranorin: Rf-7	*Lecanora formosula* Lumbsch

Figure: TLC results of site 1: Willong Khullen Samples

LIQUID CHROMATOGRAPHY MASS SPECTROMETRY (LCMS)

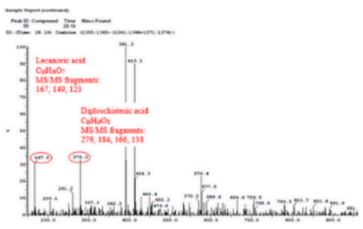
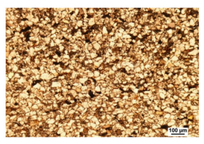


Figure LCMS (m/z) chromatogram of Sample no. WV-2 Diploschistes actinostomus (WILLONG)

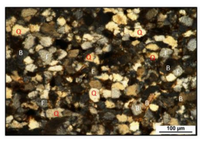
Figure: Willong Megalith 4

MINERAL IDENTIFICATION

- PETROGRAPHY



a) Textural view of the sample



b) Mineral assemblage of Quartz (Q), Feldspar (F), Schist (S), Biotite (B)

Figure: Photomicrograph of Willong sample WI in 100 µm in a) Plane polarized light (PPL) and b) Crossed-polarized light (XPL)

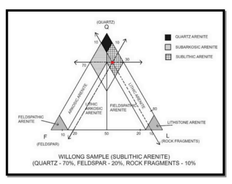
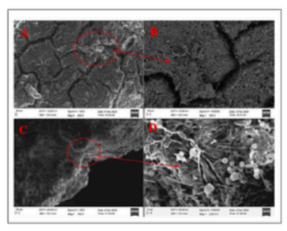


Figure : Quartz-Feldspar-Lithic fragments (QFL) ternary diagram of Willong sublithic arenite

BIODETERIORATION STUDY

- SCANNING ELECTRON MICROSCOPY-ENERGY DISPERSIVE SPECTROSCOPY (SEM-EDS)



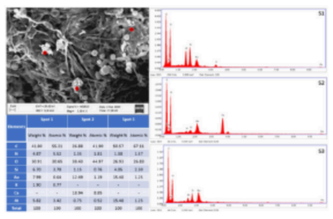


Figure: Lichen-rock EDS spectrum of Sample no. WII-2 Lecanora formosula (Willong)

Results

Lichen Identification:
- Multiple saxicolous species documented, including *Parmotrema reticulatum, Porpida albocaerulescens, Lecidella stigmatea, Lecanora formosula, Lecanora sulphurescens, Diploschistes actinostomus, Parmelia sulcata, Dirinaria applanata and Lecidea plana.*

Rock Composition:
- The petrographic identification of the mineral compositions of the selected megalithic sites shows that the Willong, Paomata and Salangthel were sedimentary rocks with quartz, feldspar, and rock fragments of biotites and schists while Pudunamei samples were Limestones with calcite, biotite and ferruginous cements.

Lichen-Induced Deterioration:
- Physical effects: *Hyphal penetration* into the rock substrate confirmed through SEM micrographs.
- Chemical effects: Presence of biomineralization products such as **calcium oxalates (weddellite, whewellite)** and **iron oxides (goethite)**, detected by SEM-EDS analysis.

Discussion

Dual Role of Lichens:
- While lichens cause biodeterioration, evidence suggests that dense lichen cover may also shield rocks from severe abiotic weathering, forming a protective calcium oxalate layer.
- The study confirms active biodeterioration processes in Manipur's megaliths, aligning with previous global studies (Jones & Wilson, 1985; Adamo & Violante, 2000).
- Chemical weathering through oxalic and carbonic acids secretion leads to mineral breakdown and secondary biomineral formation.

Prospect for future research:
- Current evidence suggests no large-scale removal; focus should be on monitoring, preventive site management, and further research.
- Priority areas include quantifying deterioration rates, exploring protective shelters, improving drainage, and preserving lichen biodiversity until more data is available.

Conclusion

Lichen colonization contributes to the weathering of Manipur's megalithic monuments through both mechanical penetration of the stone matrix and biochemical alteration of its mineral components, leading to progressive structural degradation. Nonetheless, under the region's high-rainfall climatic conditions, lichen cover may also confer a degree of surface protection by reducing direct exposure to erosive forces. This potential dual role highlights the need for comprehensive, longitudinal studies to quantify deterioration rates and to differentiate between the net destructive and protective effects of colonization. Informed by such evidence, conservation strategies should adopt a context-specific approach, integrating targeted bio-cleaning, community engagement, microclimatic monitoring, and the application of low-toxicity, sustainable preventive treatments appropriate to the environmental and cultural context of Manipur.

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