

# Lichen Flora Of The Greater Sonoran Desert Region

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## Anatomy of the endolithic Sonoran Desert lichen *Verrucaria rubrocincta* Breuss: implications for biodeterioration and biomineralization

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**Abstract:** The anatomy of the endolithic, calcicolous lichen *Verrucaria rubrocincta* Breuss is described using optical and scanning electron microscopy. This lichen is locally abundant in caliche plates of open desert pavements in the Sonoran Desert of south-western Arizona. The endolithic growth of *V. rubrocincta* is distinctly layered. The upper layer is a fine-grained calcite (micrite). This layer is sparsely penetrated by hyphae and therefore cannot be interpreted as a lithocortex *sensu stricto*. Beneath the micrite is the photobiont layer. Below this photobiont layer hyphae form a pseudomedulla penetrating up to 1 cm into the caliche. Calcium oxalates occur in the pseudomedulla but are absent from uninhabited caliche. The analogy of a greenhouse describes the ecophysiological adaptations of this endolithic growth to the environmental extremes of the Sonoran Desert. The micrite acts as a roof and the photobiont layer and pseudomedulla represent the greenhouse interior. *Verrucaria rubrocincta* has thus evolved a strategy to successfully establish and survive within an extreme environment. Our study illustrates biodeterioration and biomineralization processes acting simultaneously within a single lichen species. Mineralogical evidence suggests that the micrite on the thallus surface is biologically induced. The hyphae of the lichen biodeteriorate the caliche thus forming the pseudomedulla. Simultaneously with this process micrite forms at the surface protecting the thallus from exposure and counter-balancing rock degradation. These combined effects of biodeterioration and biomineralization do not markedly accelerate erosion because inhabited and uninhabited areas of the same plate show similar surface heights.

**Key words:** anatomy, biodeterioration, biomineralization, endolithic lichens, rock weathering, Sonoran Desert, *Verrucaria rubrocincta*.

### Introduction

Saxicolous lichens are categorized as epilithic or endolithic. It is often assumed that epilithic lichens do not penetrate their substratum. In contrast, endolithic lichens grow at least partially if not entirely within rock. This strict distinction is not as clear cut as the terminology suggests. For example, lichen hyphae from epilithic thalli were

observed penetrating rocks (Bjelland & Ekman 2000; Souza-Egipsy *et al.* 2002). However, the predominant part of an epilithic lichen thallus grows on the surface of the substratum. Endolithic growth forms are further divided into chasmo-, crypto- and euendolithic (Golubic *et al.* 1981). Chasmo-lithic lichens grow hidden between mineral grains of the rock surface whereas crypto-endolithic thalli colonize pre-existing cavities inside the rock substratum rarely reaching the surface. These cryptoendolithic lichens were first described from the Antarctic (Kappen *et al.* 1981; Friedmann 1982, Friedmann & Ocampo-Friedmann 1984), and later recognized in hot arid deserts (Lange *et al.* 1970; Wessels & Kappen

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