ROCK EATING FUNGI

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Abstract

Basalt rock weathering rates by the ectomycorrhizal fungus, *Amanita virosa* were characterized. Elemental concentrations of Ca, Mg, and Si and pH trends were analyzed. Also, scanning electron microscopy was used to examine the method of fungal weathering.

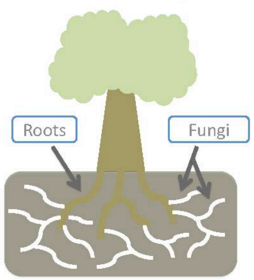
When provided with ammonium (NH_4) as a nitrogen source, the fungus clearly weathered basalt rock, appreciably releasing the elements Ca and Mg into solution. When incubated in the presence of nitrate (NO_3), considerable amounts of silicate minerals were released.

When incubated in the presence of phosphate (KH_2PO_4), the fungus weathered basalt no more quickly (and often slower) than when the only phosphorus source was present in the basalt as the mineral, apatite. This finding urged us to suggest that the fungus is actively foraging for phosphorus when it is not provided in the immediate environment.

SEM micrographs suggest direct hyphal contact during basalt weathering.

Introduction

Mycorrhizae, fungi that form symbiotic relationships with a plant host, provide their plant partner with nutrients from the soil in exchange for carbohydrates derived from photosynthesis. In nutrient-poor ecosystems, Phosphorus (P) and Nitrogen (N) are the two most common growth-limiting nutrients of plants[1]. Due to their unique physiology, mycorrhizal fungi are able to harvest nutrients (P, N, Mg, K, and Ca) from soils even when concentrations remain low. However, with the discovery of "rock-eating fungi," questions arise regarding the origin of these essential nutrients[2].
Bacteria and Lichens have been studied extensively in their role as geolytic agents, however the role of mycorrhizal fungi in mineral weathering is much less well known. Field observations provide evidence that fungi are actively weathering rock[3], but whether the fungally weathered minerals are involved in plant nutrition is less understood[4]. Fungi possess a wide array of chemical and physical tools that make them candidates for potential rock weathering:



- *Low Molecular Weight Organic Anions* (LMWOA)[6]
- *Carbonic Acid* (CO_2)[4]
- *Organic Ligands*[7]
- Organic Acids[5]
- *Fungal Appresoria*[4]

The common and geographically widespread mycorrhizal fungus, *Amanita virosa*, is readily found in symbiotic relationships with the trees Beech, Oak, Pine, and Spruce; all of which are ubiquitous inhabitants throughout the United States. Basalt, a common igneous rock, is also widespread throughout the geographic range of *A. virosa*, and throughout the crust of planet Earth. The geographic ranges of both *A. virosa* and basalt rock make them model systems for studying potentially widespread mycorrhizal-induced rock weathering as it relates to plant nutrition.

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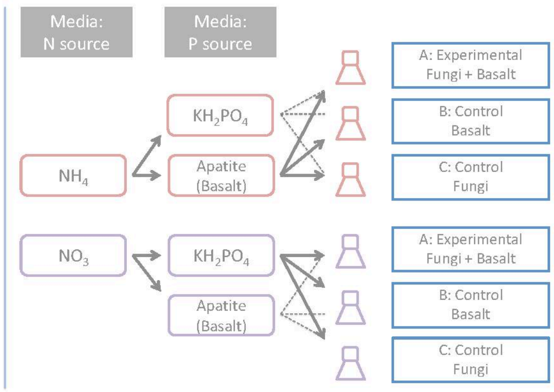
Methods

- *Amanita virosa* fruiting bodies were collected and subsequently subcultured on Modified Melin-Norkrans agar. The cultures were incubated for one week, allowing the colonies to reach a diameter of about 2 cm
- Columbia River Flood Basalt samples were broken with a hammer and subsequently crushed in a shatter box provisioned with a tungsten carbide grinding container. The crushed rock was wet sieved to segregate fragments of the 45-850 µm size

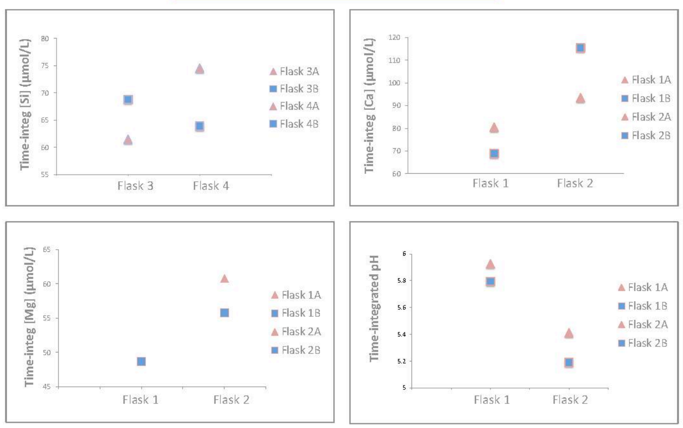
1. The appropriate media, fungi, and basalt particles were added to their corresponding reactors and allowed to incubate on a shaker table for two weeks
2. Samples of the liquid media in the reactors were taken every three days for two weeks
3. After every sampling, an aliquot of unreacted media was added to the reactor, providing a constant supply of glucose and nitrogen to the fungus

- The samples were analyzed spectrophotometrically
- Basalt samples (after incubation with the fungus) were examined under the scanning electron microscope (SEM)

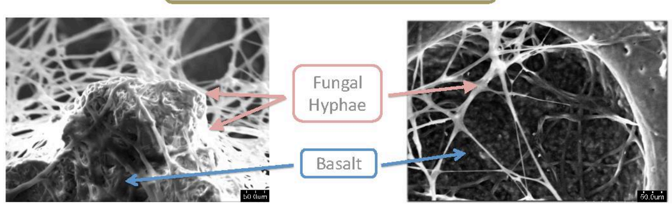


Results

Elemental and pH Data



Scanning Electron Microscopy

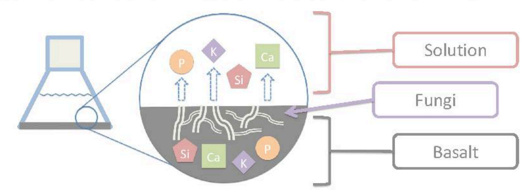


Although completely covering the basalt, the tips of the hyphae are seen "tunneling" into the basalt particle.

The round basalt particle is colonized by fungal hyphae; the hyphae have colonized the rock through etched pits.

Conclusions

- The results of this study suggest that the common ectomycorrhizal fungal species, *Amanita virosa*, is able to weather basalt rocks appreciably. The weathering capability of silicate minerals (measured by elemental release of Si) was elevated when the fungus was devoid of readily available P (H_2PO_4). This correlation seems to suggest that: when in P-limited conditions, *A. virosa* actively forages for P by exuding chemical weathering agents and actively colonizing available basalt (visible from SEM).



- The elemental release patterns shown in this study suggest that the weathering of basalt particles by *A. virosa*, when in mycorrhizal association with its plant partner, can make essential nutrients available for plants; Mg and Ca in particular. When plants receive nutrients from mycorrhizae, the fungi are given carbohydrates (derived from photosynthesis) in return. Experiments *in vitro* have found that when fungi are given excess carbon (from their plant partner), they maintain a balance with their environment by exuding large quantities of organic acids. This cycle could result in a positive feedback loop, increasing the amount of weathering agents in the soil, thereby enhancing basalt weathering.

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