Spectroscopically visualising the availability of goethite-sorbed phosphate to soil microorganisms

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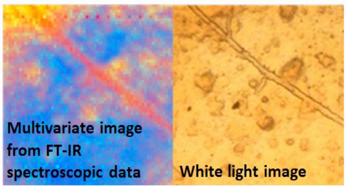
Phosphorus (P) is an essential nutrient, limiting biomass production in many soils. The biogeochemical cycling of P is highly influenced by soil minerals, such as goethite, which has the ability to strongly sorb soluble phosphates. However, the mechanisms by which soil microorganism take up sorbed phosphate is still not completely understood.

In this study we investigate whether soil microorganisms can use phosphate pre-adsorbed to goethite. To test this we ran experiments under four sets of experimental conditions; with or without P (+P/-P) and with or without glucose and nitrogen (+CN/-CN). The goethite was deposited as a mineral film on BaF_2 slides, after which the soil (clay-rich oxisol from South Africa), was deposited onto the goethite films. Prior to addition to the goethite layer, half the soil was amended with glucose and ammonium sulphate (2.0 and 0.3 g per g of soil organic matter, respectively).

The experiments were monitored over 13 days using FT-IR microspectroscopy. During this time it was found that there was no significant growth of microorganisms from the soil onto the goethite mineral film in both cases where C and N were not amended to the soil (-CN). However, in both cases where C and N are amended to the soil (+CN) we see microbial growth. When there is no P added to the mineral film (+CN/-P), we see only minimal growth of yeast cells close to the soil deposition site. When there is P added to the mineral film (+CN/+P) we see significant fungal hyphae growing out onto the goethite within 6 days of incubation. The FT-IR microspectroscopy results show distinct differences in the goethite near the fungal hyphae. These results show that goethite-sorbed P is bioavailable and can greatly affect the soil microbial growth.

Blue: Phosphates
Red: Carbohydrates, proteins, lipids
Yellow: increase in polysaccharides



Submarine meteorite impact craters as potential cradles of life: Mineralogical evidence from the Onaping Formation, Sudbury

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A difference between terrestrial versus lunar and martian impact basins is the possibility of submarine impacts. The thick meltsheet of a very large terrestrial impact acts as an effective heat source below water-filled craters and can potentially sustain prolonged phreatomagmatic activity. The Sudbury impact basin, Ontario, Canada, is the largest accessible and well-preserved example of a submarine impact. Although it is mainly known for its magmatic sulphide Ni-Cu deposits, it also hosts a number of VMS-type base metal deposits in the crater fill. Using observations from the fill, we highlight the potential importance of submarine meteorite impact craters as a location for the development of the life on the heavily bombarded early Earth.

We report the discovery of monocrystalline igneous quartz in the Onaping Fm. of the Sudbury crater fill – a complex unit composed of both the immediate fall-back of brecciated impact material and also later-formed igneous rocks. The crystallisation temperatures of the quartz grains have been calculated by applying the titanium-in-quartz thermometer to titanium contents obtained by LA-ICP-MS.

This finding provides support for continued in-crater igneous activity after the initial impact (e.g. [1]), and thus highlights the potential of submarine impact craters as sites where life might have emerged. Submarine Hadean impacts were likely common (e.g. [2]) as there is evidence for a liquid hydrosphere at this time (e.g. from abundance of halogens; [3]). From an emergence of life point of view, submarine craters are contained, confined bodies of water surrounded by highly friable rock, supporting a very high nutrient load. In addition, the hydrothermal processing of this fluid at volcanic vents was an effective factory for creating complex precursor molecules. Interestingly, the upper half of the Onaping Fm., like the overlying sedimentary Onwatin Fm., is rich in isotopically light [4] reduced carbon of possibly biologic origin (e.g. [5]).

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