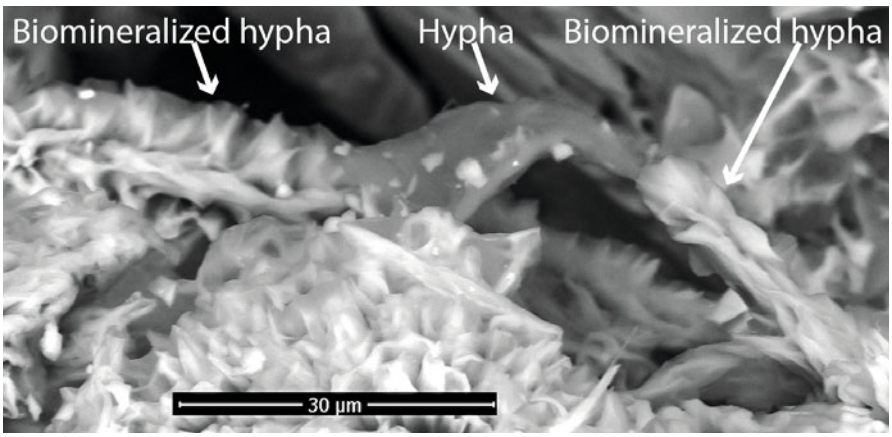
Fungi in anaerobic consortia in granite 740 m down

The occurrence of prokaryotes in rock even several kilometres below the Earth's surface has been recognized for over a decade. Although there have also been some reports of fungi from marine sediments and sub-seafloor basalts, a group of researchers from Germany and Sweden have discovered consortia of fungi and sulphate reducing bacteria in continental rocks 740 m below the surface (Drake *et al*. 2017). The assemblage was found in a drill core from Sweden undertaken in connection with an investigation for potential sites for a nuclear waste repository. Mycelial-like networks were discovered in a fracture in a metre-wide quartz vein, found by Raman spectroscopy to be coated with a euhedral zeolite identified as cowlesite, along with calcite, pyrite, and clay minerals. The hyphae were crystalline and partly organically preserved and partly mineralized. In addition to direct observations by Environmental Scanning Electron Micrograph (ESEM), the group also used synchrotron techniques and stable isotope analysis to demonstrate a connection between the fungi and sulphate reducing bacteria present in the same samples. The fungi were interpreted as anaerobic because of the environmental situation in which they were found and the minerology. No further information as to the identity of the fungi involved could be obtained, no sporing structures were reported, and no DNA characterization appears to have been attempted. In addition to identifying a previously unexpected niche occupied by fungi in continental land masses, the authors express concern that they might jeopardize the safe disposal of toxic wastes deep below the Earth surface.

Drake H, Ivarsson M, Bengtson S, Heim C, Siljeström S, *et al.* (2017) Anaerobic consortia of fungi and sulfate reducing bacteria in deep granite fractures. *Nature Communications* **8**: 55.



ESEM image of a partly preserved and partly mineralized fungal hypha. Photo: reproduced with modifications from Drake *et al*. 2017), courtesy Henrik Drake.

Trouble over cap colours and species concepts in *Russula*

There can be few field mycologists who have not struggled with trying to categorize basidiome cap colours when trying to put a name to a collection they made of a *Russula*. A major study analyzing cap colour and the ITS2 rDNa region demonstrates why this is such a problem. Bazzicalupo *et al.* (2017) studied 713 specimens from the Pacific Northwest collected by Benjamin Woo, and then included sequences from 50 European and other North American specimens from major clades in the genus. The molecular data indicated the delimitation of 72 phylogenetic species, of which just 28 matched sequences from type or other barcoded material from Europe; 44 species were therefore poorly known or undescribed. They then went on to compare morphological and molecular data in 23 species of which they had 10 or more collections. No morphological character alone proved to be diagnostic in any of those 23 species, and just 48.5 % of the specimens were found to have been correctly named. If a 50:50 chance of being correct is the best specialists can do, no wonder that field mycologists have problems.

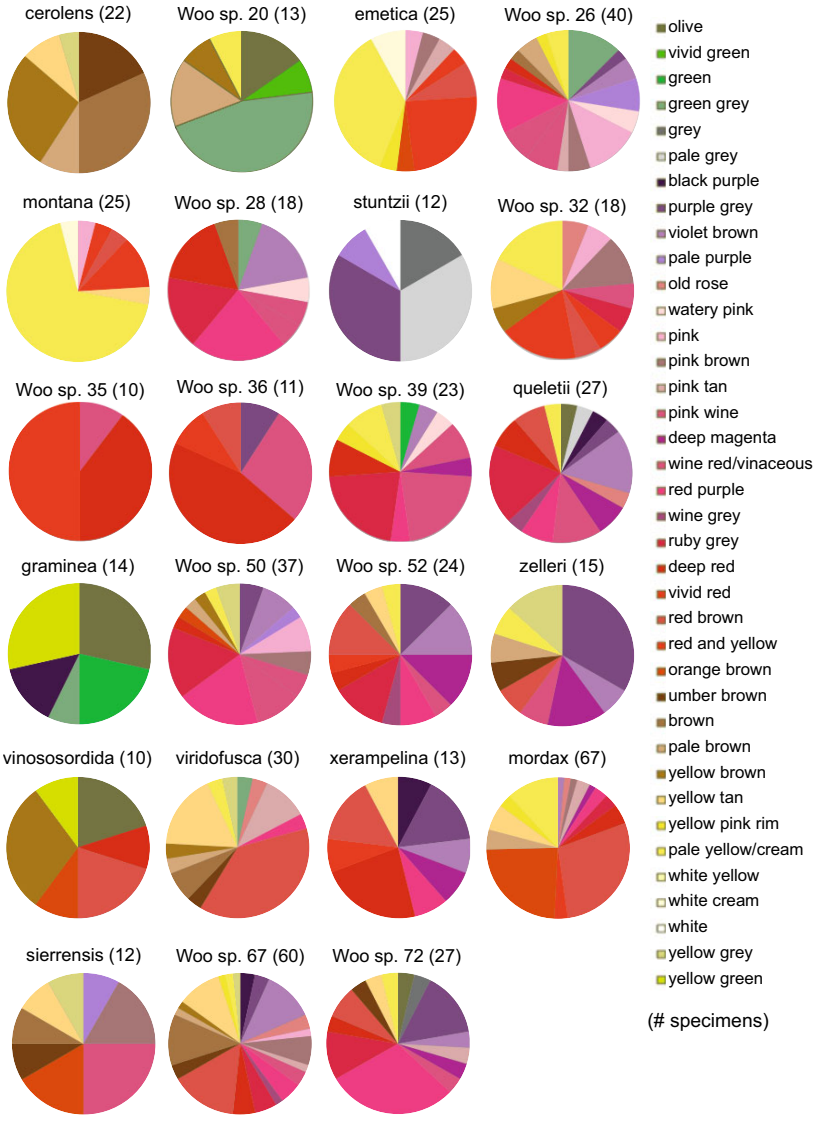
Woo sp. 67, to be described shortly as *Russula benwooii* in *Fungal Diversity*. Photo: Benjamin Woo.

The variation in cap colours in different specimens belonging to the same species was

especially striking and represented in a figure by pie-charts reproduced here. The more the collections, the more variation in colour was documented. Note for example the chart for Woo sp. 67 (basidiomes of which are also illustrated here) of which 60 collections were available.

Incorrect morphologically based identifications of *Russula* must abound in databases worldwide, frustrating true assessments of which species are mycorrhizal with particular trees, geographical distributions, and conservation status. This problem will have to borne in mind when endeavouring to reach conclusions in any of these key areas. Frustratingly for field mycologists, the reality that morphology lags behind in speciation processes in the genus has to be accepted.

Bazzicalupo AL, Buyck B, Saar I, Vauras J, Darmean D, Berbee ML (2017) Troubles with mycorrhizal mushroom identification where morphological differentiation lags behind barcode sequence divergence. *Taxon* **66**: 791–810.



Variation in cap colours of conspecific *Russula* species. The numbers in brackets after the species names (or codes for unnamed species) indicate the number of specimens assessed. Reproduced from Bazzicalupo *et al.* (2017).

Fungal diseases influence wine aromas

Those who enjoy wine will be familiar with the "nose", the aroma which can help differentiate between wines and be indicative of quality. *Botrytis cinerea* (cause of Bunch rot) and *Erysiphe necator* (powdery mildew) have been implicated in contributing to the sought-after aromas, but with the increased use of fungicides in viticulture the fungi are becoming increasingly restricted. Pinar *et al.* (2017) investigated this by collecting, on the same day, infected and uninfected grapes from a grape cultivar used in the production of three German wines. The juice extracted from each category was then fermented with a re-activated pure culture of *Saccharomyces cerevisae* for 2–3 wk, racked, adjusted to similar sulphur dioxide levels, sterile-filtered, and bottled. Volatiles were later extracted chemically and analyzed by a range of sophisticated analytical instruments, and further by 10 panelists who had all been trained for at least six months in recognizing and naming about 80 selected aromas.

Fifty-one odourous compounds were detected by Gas Chromatography Olfactometry Analysis (GC-O) and the predominant 31 characterized chemically. The differences in aroma analysed by the panel, however, revealed that there was not a simple correlation with particular compounds in what they sensed, but that the differences were due to quantitative variations in a mixture of diverse substances. The wine from *Botrytis* infected grapes was in all cases rated as more pleasant than that from uninfected grapes, imparting a stronger peach-like, fruity, floral and liquor-like aroma. In contrast, that from *Erysiphe* infected grapes was scored as less pleasant than that from uninfected grapes, and also had a decreased vanilla-like essence.

Growers seeking to produce wines with rich fruity aromas should perhaps consider exploring ways to promote *Botrytis*

infections while simultaneously eliminating those of *Erysiphe*. For mycologists, if your nose detects a rich fruity smell or floral smell in your wine, it may well have come from *Botrytis* infected grapes,

Pinar AL, Rauhut D, Ruehl E, Buettner A (2017) Effects of bunch rot (*Botrytis cinerea*) and powdery mildew (*Erysiphe necator*) fungal diseases on wine aroma. *Frontiers in Chemistry* **5**: article 20.

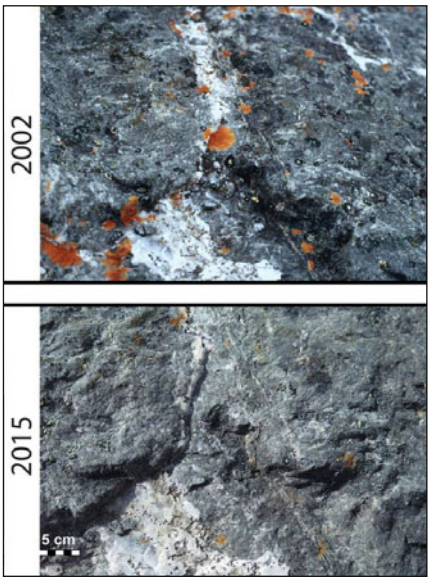
Warming and cooling events in Antarctica affect lichen communities

There is a long history of monitoring lichen growth rates in the Antarctic Peninsula, and this report is based on observations of data from six species on recently de-glaciated surfaces over the 24 years 1991–2015. The species monitored were five crustose (*Acarospora macrocyclos, Bellemerea* sp., *Buellia latemarginata, Caloplaca sublobulata* and *Rhizocarpon geographicum*) and one shrubby (fruticose) species (*Usnea antarctica*). There was almost no change in the growth rate of the *Buellia,* the fastest growing species at a mean of 0.79 mm/yr. However, the *Bellemerea*, *Rhizocarpon* and *Usnea* all showed an increase in growth of 0.35–0.40 mm/yr over 1991–2002, followed by a decline in 2015. The *Acarospora* and *Caloplaca* initially grew at rates comparable to that of the *Bellemerea*, but showed a massive decline from 2002–15. The change is described as "catastrophic" and attributed to increased snow fall persisting on the ground for longer. It is argued that a biological "tipping point" has been reached, a threshold after which snow cover duration leads to lichen death – a phenomenon that has been termed "snowkill".

Usnea antarctica, however, responded differently. There was no evidence of adverse effects from increased snow fall, attributable to the lichen tending to grow on the most exposed rock surfaces. The changes documented have taken place with just a 0.58 °C rise in mean air temperature, and in the case of *U. antarctica* the growth rate increased by 26 % indicating that this species has particular potential as a sensitive tracker for changing ambient temperatures.

Usnea antarctica. Photo: Leopoldo Sancho.

Sancho LG, Pintado A, Navarro F, Ramos M, Angel De Pablo M, *et al.* (2017) Recent warming and cooling in the Antarctic Peninsula region has rapid and large effects on lichen vegetation. *Nature, Scientific Reports* 7: 56589.



Lichen cover on a boulder on Livingstone Island, South Shetland Islands, in 2002 and 2015. Photo: courtesy of Leopoldo Sancho.

Yeast morphs in *Pucciniomycota* re-evaluated

Franz Oberwinkler, IMA President from 1994–98, and one of the most respected mycologists worldwide, who is renowned for his pioneering and insightful work on the ultrastructure and systematics of basidiomycete, has now produced an overview of the yeast-like morphs in the subphylum *Pucciniomycota*. These morphs are especially prevalent in basal basidiomycete lineages, but appear to have been lost in most others. Fifteen orders distributed through eight of the ten accepted classes of the subphylum have such morphs. These are treated order by order with numerous illustrations and copious references to the pertinent literature.

In each case there is a "Comments" section, and attention is drawn here to that under *Cyphobasidiales* as it will be of considerable interest to non-systematists and indeed biologists more generally. It was claimed last year that yeast-morphs belonging to the order might be an integral component of at least some lichen symbioses, and affecting the extrolites produced. This speculation arose as a result of discoveries using elegant cutting-edge transcriptomics and fluorescence imaging (Spribille *et al.* 2016; *see IMA Fungus* 7(2): (65)–(66), 2017); the work even featured on the cover of *Science*, and attracted much public interest. However, the fungi involved are known as gall-formers on lichens, and after careful analysis Oberwinkler concludes

"that basidiomycetous yeasts in lichen thalli are not a third component of symbiosis, but rather the vegetative propagules of mycoparasites" (p. 842).

Oberwinkler F (2017) Yeasts in *Pucciniomycotina*. *Mycological Progress* **16**: 821–856.

STOP PRESS!

Prototaxites WAS an ascomycete and may have been lichenized

The nature of the enigmatic fossil genus *Prototaxites*, which forms conical growths that can be to 9 m tall in Silurian to Upper Devonian deposits has been hotly debated. A report that one species has been found fertile is scheduled to be published on 18 December 2017 (Honegger *et al*. 2017), about the time this issue of *IMA Fungus* will be generally available. This research will be reported on in more detail in the June *IMA Fungus,* but mycologists will be excited to learn that this species was a ascomycete with asci formed over the surface, and that it was lichenized cannot be ruled out. Do look at the paper when it appears!

Honegger R, Edwards D, Axe L, Strullu C (2017) Fertile *Prototaxites taiti*: a basal ascomycete with inoperculate polysporous asci lacking croziers. *Philosophical Transactions of the Royal Society, B, Biological Sciences* **373**: 20170146.