

Research conducted throughout the Russian invasion is helping save Ukraine's historic artworks

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Assessing damage of the 11th century frescoes in St Sophia's Cathedral Kyiv.
Credit: Marina Fomina/ National Academy of Sciences of Ukraine

Researchers from the Natural History in London have collaborated with researchers from the National Academy of Sciences of Ukraine to establish the cause of damage to the world-famous medieval murals in Kyiv's Saint Sophia Cathedral—one of Ukraine's most important cultural sites.

These murals, which were painted on the walls of the Saint Sophia cathedral in around 1000CE, are some of Ukraine's most significant artworks. It had become apparent they were under threat when they began to develop dark spots and flaking away. In a bid to protect and restore the art, research was carried out to establish the type of microscopic organisms that were living on the walls and causing this damage.

The research began long before the Russian invasion of Ukraine and was disrupted by the attacks on the country—which also included attacks on the country's unique cultural treasures.

Initial investigations in Kyiv involved the Ukrainian team taking DNA samples from the walls of degraded areas of the cathedral and then comparing these to samples from areas free of damage. From this, they were able to see that, whilst the levels of bacteria in both regions were similar, the damaged parts of the church had much higher levels of fungal DNA.

The Ukrainian researchers discovered cracks and voids within the fabric of the walls and some unusual large crystals that were entirely unlike the general fabric of the [plaster](#). A chemical assessment concluded that this was an organic substance secreted by the fungi.

Research, using microscopic techniques at the Natural History Museum in London established that the crystals were calcium malate, a by-product of malic acid secreted by the fungi to feed on inorganic nutrients

in the plaster. The fungi were dissolving the plaster and producing crystals that were tearing the plaster fabric.

The crystals are formed from the reaction between the malic acid and the calcium from the plaster. Malate is a very common substance, produced in the cells of every living organism, but very rarely excreted. It has been reported in murals only two times before, in the Monastery of Pedralbes in Barcelona and in the tomb of Tutankhamun.

The presence of abundant calcium malate in the damaged areas poses an important question probably linked to fungal adaptation. For some unknown reason, researchers think, the environmental condition of the cathedral is causing the fungi to release it, rather than other much more common substances. The crystals deposited within and behind the plaster work are breaking it apart and causing it to degrade.

Now that the researchers in Kyiv know exactly what is going on in the walls of the cathedral, they hope to be able to prevent it and preserve the murals for years to come.

Ukrainian researcher Marina Fomina, lead author on the paper, says, "Russia's attempts to violently destroy and assimilate so much of our [cultural identity](#) meant the work to preserve Saint Sophia and this precious artwork was even more urgent. It is a huge relief to understand the cause of this damage and enable its conservation for our national and the world's cultural heritage."

Dr. Javier Cuadros, a senior researcher at the Natural History Museum and a co-author of the paper, played a crucial role in getting the paper over the finishing line.

"We were collaborating with them throughout this devastating time. However, when Kyiv was attacked it was impossible for our colleagues

to continue working because they had to suspend everyday life and flee their homes.

"I'm very happy to have been able to play a role in this research. The discovery means a lot to our Ukrainian colleagues and will help preserve their legacy and other historic artworks for future generations.

"Hearing about the support they gave each other in their communities has been a lesson in human solidarity and maintaining cohesion in the most challenging of times. We dedicated the paper to the courageous Ukrainian people whose resilience is so admirable."

The paper is published in the November 2022 edition of *International Biodeterioration & Biodegradation*.

More information: Marina Fomina et al, Fungal transformation of mineral substrata of biodeteriorated medieval murals in Saint Sophia's cathedral, Kyiv, Ukraine, *International Biodeterioration & Biodegradation* (2022). [DOI: 10.1016/j.ibiod.2022.105486](https://doi.org/10.1016/j.ibiod.2022.105486)

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