

**Table S1.** List of all the references associate to each site defined in the analyses.

Site number	Environmental category	References
Site1	C-HE	[1-8]
Site2	C-HE	[9]
Site3	C-HE	[10]
Site4	C-HE	[11]
Site5	C-HE	[12-14]
Site6	C-HE	[15,16]
Site7	C-HE	[17]
Site8	C-HE	[18]
Site9	C-HE	[19]
Site10	C-HE	[20]
Site11	C-HE	[21-23]
Site12	C-HE	[24]
Site13	C-HE	[25,26]
Site14	C-HE	[27]
Site15	NC-HE	[28]
Site16	NC-HE	[29-31]
Site17	NC-HE	[32]
Site18	NC-HE	[33]
Site19	NC-HE	[34,35]
Site20	NC-HE	[36]
Site21	NC-HE	[37]
Site22	NC-HE	[38]
Site23	NC-HE	[39]
Site24	NC-HE	[40]
Site25	NC-HE	[41,42]
Site26	NC-HE	[43]
Site27	NC-HE	[44-49]
Site28	C-NHE	[50,51]
Site29	C-NHE	[52,53]
Site30	C-NHE	[53]
Site31	C-NHE	[53]
Site32	C-NHE	[54]
Site33	C-NHE	[55]
Site34	C-NHE	[56]
Site35	C-NHE	[57,58]
Site36	C-NHE	[59]
Site37	C-NHE	[60]
Site38	C-NHE	[61]
Site39	C-NHE	[62]
Site40	C-NHE	[63-65]
Site41	C-NHE	[66,67]
Site42	C-NHE	[68]
Site43	C-NHE	[69]

Site44	C-NHE	[70,71]
Site45	C-NHE	[72]
Site46	C-NHE	[73]
Site47	C-NHE	[74]
Site48	C-NHE	[75]
Site49	C-NHE	[76]
Site50	C-NHE	[77]
Site51	C-NHE	[78,79]
Site52	C-NHE	[80]
Site53	C-NHE	[81]
Site54	C-NHE	[82]
Site55	C-NHE	[83]
Site56	C-NHE	[76]
Site57	C-NHE	[84]
Site58	C-NHE	[84]
Site59	C-NHE	[84]
Site60	C-NHE	[84]
Site61	C-NHE	[85]
Site62	C-NHE	[86]
Site63	C-NHE	[97]
Site64	C-NHE	[16]
Site65	C-NHE	[88]
Site66	C-NHE	[89]
Site67	C-NHE	[90]
Site68	SC-NHE	[91]
Site69	SC-NHE	[92]
Site70	SC-NHE	[93]
Site71	O-SPE	[94]
Site72	O-SPE	[95]
Site73	O-SPE	[96]
Site74	O-SPE	[97-100]

## References

1. Sugiyama, J.; Kiyuna, T.; An, K. D.; Nagatsuka, Y.; Handa, Y.; Tazato, N.; Hata-Tomita, J.; Nishijima, M.; Koide, T.; Yaguchi, Y.; Kigawa, R.; Sano, C.; Miura, S. Microbiological survey of the stone chambers of Takamatsuzuka and Kitora tumuli, Nara Prefecture, Japan: a milestone in elucidating the cause of biodeterioration of mural paintings. In *International symposium on the conservation and restoration of cultural property: study of environmental conditions surrounding cultural properties and their protective measures*. National Research Institute for Cultural Properties, Tokyo **2009**, pp. 51–73. DOI: 10.1.1.619.5561
2. Kiyuna, T.; An, K.D.; Kigawa, R.; Sano, C.; Miura, S.; Sugiyama, J. Molecular assessment of fungi in “black spots” that deface murals in the Takamatsuzuka and Kitora Tumuli in Japan: *Acremonium* sect. *Gliomastix* including *Acremonium tumulicola* sp. nov. and *Acremonium felinum* comb. nov. *Mycoscience* **2011**, *52*, 1–17. DOI: 10.1007/S10267-010-0063-6
3. Kiyuna, T.; An, K.D.; Kigawa, R.; Sano, C.; Miura, S.; Sugiyama, J. Mycobiota of the Takamatsuzuka and Kitora Tumuli in Japan, focusing on the molecular phylogenetic diversity of *Fusarium* and *Trichoderma*. *Mycoscience* **2008**, *49*, 298–311. DOI: 10.1007/S10267-008-0427-3
4. An, K.D.; Kiyuna, T.; Kigawa, R.; Sano, C.; Miura, S.; Sugiyama, J. The identity of *Penicillium* sp. 1, a major contaminant of the stone chambers in the Takamatsuzuka and Kitora Tumuli in Japan, is *Penicillium paneum*. *Anton. van Leeuw.* **2009**, *96*, 579. DOI: 10.1007/s10482-009-9373-0
5. Sugiyama, J.; Kiyuna, T.; Nishijima, M.; An, K.D.; Nagatsuka, Y.; Tazato, N.; Handa, Y.; Handa-Tomita, J.; Sato, Y.; Kigawa, R.; Sano, C. Polyphasic insights into the microbiomes of the Takamatsuzuka tumulus and Kitora tumulus. *J. Gen. Appl. Microbiol.* **2017**, *63*, 63–113. DOI:10.2323/jgam.2017.01.007
6. Nagatsuka, Y.; Kiyuna, T.; Kigawa, R.; Sano, C.; Miura, S.; Sugiyama, J. *Candida tumulicola* sp. nov. and *Candida takamatsuzukensis* sp. nov., novel yeast species assignable to the *Candida membranifaciens* clade, isolated from the stone chamber of the Takamatsuzuka tumulus. *Int. J. Syst. Evol. Microbiol.* **2009**, *59*, 186–194. DOI:10.1099/ijs.0.65830-0
7. Kiyuna, T.; An, K.D.; Kigawa, R.; Sano, C.; Miura, S.; Sugiyama, J. Bristle-like fungal colonizers on the stone walls of the Kitora and Takamatsuzuka Tumuli are identified as *Kendrickiella phycomyces*. *Mycoscience* **2012**, *53*, 446–459. DOI:10.1007/S10267-012-0189-9
8. Kiyuna, T.; An, K.D.; Kigawa, R.; Sano, C.; Sugiyama, J. Two new *Cladophialophora* species, *C. tumbae* sp. nov. and *C. tumulicola* sp. nov., and chaetothyrialean fungi from biodeteriorated samples in the Takamatsuzuka and Kitora Tumuli. *Mycoscience* **2018**, *59*, 75–84. DOI: 10.1016/j.myc.2017.08.008
9. Emoto, Y. Microbiological investigation of ancient tombs with paintings: Ozuka tomb in Fukuoka and Chibusan tomb in Kumamoto. *Sci Conserv.* **1974**, *12*, 95–102.
10. Barbieri, N.; Bassi, M.; Dassù, G.; Rossi, F. Gli affreschi del tempio repubblicano di Brescia: condizioni ambientali ed inquinamento microbiologico. *Arte Lombarda* **1986**, *76/77*, 113–117.
11. Arai, H. The environmental analysis of archaeological sites. *TrAC Trends in Analytical Chemistry* **1990**, *9*, 213–216.
12. Gambino, M.; Ahmed, M.A.A.A.; Villa, F.; Cappitelli, F. Zinc oxide nanoparticles hinder fungal biofilm development in an ancient Egyptian tomb. *Int. Biodeter. Biodegr.* **2017**, *122*, 92–99. DOI:10.1016/j.ibiod.2017.05.011
13. 88] Arai, H. Relationship between fungi and brown spots found in various materials. In: *Biodeterioration of cultural property*, Proceedings of the 2<sup>nd</sup> international conference, October 5–8, 1992, Yokohama, Japan; **1993**, 320–336.
14. Vasanthakumar, A.; DeAraujo, A.; Mazurek, J.; Schilling, M.; Mitchell, R. Microbiological survey for analysis of the brown spots on the walls of the tomb of King Tutankhamun. *Int. Biodeter. Biodegr.* **2013**, *79*, 56–63. DOI:10.1016/j.ibiod.2013.01.014
15. Sakr, A.; Ghaly, M.; Helal, G.; Abdel Haliem, M. Effect of thymol against fungi deteriorating mural paintings at Tell Basta tombs, Lower Egypt. *Int. J. Res. Stud. Biosci.* **2012**, *6*, 8–23. DOI:10.20431/2349-0365.0602003
16. Stoyancheva, G.; Krumova, E.; Kostadinova, N.; Miteva-Staleva, J.; Grozdanov, P.; Ghaly, M.F.; Sakr, A.A.; Angelova, M. Biodiversity of contaminant fungi at different coloured materials in ancient Egypt Tombs and Mosques. *Cr. Acad. Bul. Sci.* **2018**, *71*. DOI: 10.7546/CRABS.2018.07.06
17. Khalaphallah, R.; El-Derby, A.A. The effect of nano-TiO<sub>2</sub> and plant extracts on microbial strains isolated from Theban ancient Egyptian royal tomb painting. *Afr. J. Microbiol. Res.* **2015**, *9*, 1424–1430. DOI: 10.5897/AJMR2015.7432
18. Elhagrassy, A.F. Isolation and characterization of actinomycetes from mural paintings of Snu-Sert-Ankh tomb, their antimicrobial activity, and their biodeterioration. *Microbiol. Res.* **2018**, *216*, 47–55. DOI:10.1016/j.micres.2018.08.005

19. Helmi, F.M.; Elmitwalli, H.R.; Rizk, M.A.; Hagrassy, A.F. Antibiotic extraction as a recent biocontrol method for *Aspergillus niger* and *Aspergillus flavus* fungi in ancient Egyptian mural paintings. *Mediterr. Archaeol. Arc.* **2011**, *11*, 1–7.
20. Stomeo, F.; Portillo, M.C.; Gonzalez, J.M. Assessment of bacterial and fungal growth on natural substrates: consequences for preserving caves with prehistoric paintings. *Curr. Microbiol.* **2009**, *59*, 321–325. DOI:10.1007/s00284-009-9437-4
21. Dupont, J.; Jacquet, C.; Denetiere, B.; Lacoste, S.; Bousta, F.; Orial, G.; Cruaud, C.; Couloux, A.; Roquebert, M.F. Invasion of the French Paleolithic painted cave of Lascaux by members of the *Fusarium solani* species complex. *Mycologia* **2007**, *99*, 526–533. DOI:10.1080/15572536.2007.11832546
22. Martin-Sanchez, P.M.; Nováková, A.; Bastian, F.; Alabouvette, C.; Saiz-Jimenez, C. Two new species of the genus *Ochroconis*, *O. lascauxensis* and *O. anomala* isolated from black stains in Lascaux Cave, France. *Fungal Biol.* **2012**, *116*, 574–589. DOI: 10.1016/j.funbio.2012.02.006
23. Martin-Sanchez, P.M.; Nováková, A.; Bastian, F.; Alabouvette, C.; Saiz-Jimenez, C. Use of biocides for the control of fungal outbreaks in subterranean environments: the case of the Lascaux Cave in France. *Envir. Sci. Tech.* **2012**, *46*, 3762–3770. DOI:10.1021/es2040625
24. Jeong, S.H.; Lee, H.J.; Lee, M.Y.; Chung, Y.J. Conservation environment for mural tomb in Goa-ri, Goryeong. *J. Cons. Sci.* **2017**, *33*, 189–201. DOI:10.12654/JCS.2017.33.3.04
25. Isola, D.; Zucconi, L.; Cecchini, A.; Caneva, G. Dark-pigmented biodeteriogenic fungi in Etruscan tombs: new data on their culture dependent diversity and favouring conditions. *Fungal Biol.* **2021**, *125*, 609–620. DOI:10.1016/j.funbio.2021.03.003
26. Sprocati, A.R.; Alisi, C.; Tasso, F.; Vedovato, E.; Barbabietola, N.; Cremisini, C. A microbiological survey of the Etruscan Mercareccia tomb (Italy): contribution of microorganisms to deterioration and restoration. In *Art 2008*, Proceedings of the 9<sup>th</sup> International Conference on NDT of Art, Jerusalem, Israel, 25–30 May 2008; **2008**, 9 pp.
27. Ma, W.; Wu, F.; Tian, T.; He, D.; Zhang, Q.; Gu, J-D.; Duand, Y.; Mae, D.; Wang, W.; Feng, H. Fungal diversity and its contribution to the biodeterioration of mural paintings in two 1700-year-old tombs of China. *Int. Biodeter. Biodegr.* **2020**, *152*, 104972. DOI:10.1016/j.ibiod.2020.104972
28. Ma, Y.; Zhang, H.; Du, Y.; Tian, T.; Xiang, T.; Liu, X.; Wu, F.; An, L.; Wang, W.; Gu, J-D.; Feng, H. The community distribution of bacteria and fungi on ancient wall paintings of the Mogao Grottoes. *Sci. Rep.* **2015**, *5*, 7752. DOI: 10.1038/srep07752
29. Caneva, G.; Bartoli, F.; Fontani, M.; Mazzeschi, D.; Visca, P. Changes in biodeterioration patterns of mural paintings: Multi-temporal mapping for a preventive conservation strategy in the Crypt of the Original Sin (Matera, Italy). *J. Cult. Herit.* **2019**, *40*, 59–68. DOI: 10.1016/j.culher.2019.05.011
30. Nugari, M.P.; Pietrini, A.M.; Caneva, G.; Imperi, F.; Visca, P. Biodeterioration of mural paintings in a rocky habitat: The Crypt of the Original Sin (Matera, Italy). *Int. Biodeter. Biodegr.* **2009**, *63*, 705–711. DOI: 10.1016/j.ibiod.2009.03.013
31. Mang, S.M.; Scrano, L.; Camele, I. Preliminary studies on fungal contamination of two rupestrian churches from Matera (Southern Italy). *Sustainability* **2020**, *12*, 6988. DOI:10.3390/su12176988
32. He, D.; Wu, F.; Ma, W.; Zhang, Y.; Gu, J-D.; Duan, Y.; Xu, R.; Feng, H.; Wang, W.; Li, S-W. Insights into the bacterial and fungal communities and microbiome that causes a microbe outbreak on ancient wall paintings in the Maijishan Grottoes. *Int. Biodeter. Biodegr.* **2021**, *163*, 105250. DOI:10.1016/j.ibiod.2021.105250
33. Bianchi, A.; Favali, M.A.; Barbieri, N.; Bassi, M. The use of fungicides on mold-covered frescoes in S. Eusebio in Pavia. *Int. Biodeterior. Bull.* **1980**, *16*, 45–51.
34. Gorbushina, A.A.; Petersen, K. Distribution of microorganisms on ancient wall paintings as related to associated faunal elements. *Int. Biodeter. Biodegr.* **2000**, *46*, 277–284. DOI:10.1016/S0964-8305(00)00103-7
35. Gorbushina, A.A.; Heyrman, J.; Dornieden, T.; Gonzalez-Delvalle, M.; Krumbein, W.E.; Laiz, L.; Petersen, L.; Saiz-Jimenez, C.; Swings, J. Bacterial and fungal diversity and biodeterioration problems in mural painting environments of St. Martins church (Greene–Kreinsen, Germany). *Int. Biodeter. Biodegr.* **2004**, *53*, 13–24. DOI:10.1016/j.ibiod.2003.07.003
36. Leplat, J.; Francois, A.; Bousta, F. White fungal covering on the wall paintings of the Saint-Savin-sur-Gartempe Abbey church crypt: A case study. *Int. Biodeter. Biodegr.* **2017**, *122*, 29–37. DOI:10.1016/j.ibiod.2017.04.007
37. Sun, J.Z.; Ge, Q.Y.; Zhu, Z.B.; Zhang, X.L.; Liu, X.Z. Three dominating hypocrealean fungi of the ‘white mold spots’ on acrylic varnish coatings of the murals in a Koguryo tomb in China. *Phytotaxa* **2019**, *397*, 225–236. DOI: 10.11646/phytotaxa.397.3.2

38. Bartolini, M.; Nugari, M.P.; Pietrini, A.M.; Ricci, S.; Roccardi, A.; Filetici, M.G. Gli ambienti ipogei delle domus romane al Celio: indagini biologiche per il controllo e la prevenzione del biodeterioramento. *Kermes: la rivista del restauro* **2010**, *23*, 45–54.
39. Di Carlo, E.; Chisesi, R.; Barresi, G.; Barbaro, S.; Lombardo, G.; Rotolo, V.; Palla, F. Fungi and bacteria in indoor Cultural Heritage environments: microbial-related risks for artworks and human health. *Environ. Ecol. Res.* **2016**, *4*, 257–264. DOI:10.13189/eer.2016.040504
40. Palla, F.; Billeci, N.; Mancuso, F.P.; Pellegrino, L.; Lorusso, L.C. Microscopy and molecular biology techniques for the study of biocenosis diversity in semi-confined environments. *Conserv. Sci. in Cultural Heritage* **2010**, *10*, 185–194. DOI:10.6092/issn.1973-9494/2324
41. Albertano, P.; Urzì, C. Structural interactions among epilithic cyanobacteria and heterotrophic microorganisms in Roman hypogea. *Microb. Ecol.* **1999**, *38*, 244–252. DOI: 10.1007/s002489900170
42. Saarela, M.; Alakomi, H.L.; Suihko, M.L.; Maunuksela, L.; Raaska, L.; Mattila-Sandholm, T. Heterotrophic microorganisms in air and biofilm samples from Roman catacombs, with special emphasis on actinobacteria and fungi. *Int. Biodeter. Biodegr.* **2004**, *54*, 27–37. DOI:10.1016/j.ibiod.2003.12.003
43. Agarossi, G.; Ferrari, R.; Monte, M. Biocides in the control of biodeterioration. In *The conservation of monuments in the Mediterranean Basin*. Proceedings of the first International Symposium, Bari, 1989; Grafo Edizioni, **1990**, 511–517.
44. Agrawal, O.P.; Dhawan, S.; Garg, K.L.; Shaheen, F.; Pathak, N.; Misra, A. Study of biodeterioration of the Ajanta wall paintings. *Int. Biodeterior.* **1988**, *24*, 121–129. DOI: 10.1016/0265-3036(88)90054-1
45. Tilak, S.T. Biodeterioration of paintings in Ajanta. In: *Biodeterioration of Cultural Property*; Agrawal, O.P., Dhawan, S., Eds.; Macmillan, New Delhi, India, **1991**; pp. 204–212.
46. Garg, K.L.; Dhawan, S.; Bhatnagar, I.K. Microbicides for preservation of wall paintings. In: *Biodeterioration and Biodegradation*, Rossmore H.W.; **1991**, *8*, 505–507.
47. Dhawan, S.; Misra, A.; Garg, K.L.; Pathak, N. Laboratory evaluation of orto-phenyl-phenol and p-chloro-m-cresol for the control of some fungal forms of Ajanta wall paintings. In *Biodeterioration of Cultural Property*, Agrawal, O.P., Dhawan, S., Eds., Macmillan, New Delhi, India **1991**, pp. 313–338.
48. Dhawan, S.; Garg, K.L.; Pathak, N. Microbial analysis of Ajanta wall paintings & their possible control in situ. In *Biodeterioration of cultural property*, 2. Proceedings of the 2<sup>nd</sup> International Conference, October 5-8, 1992, Yokohama, Japan, International Communications Specialists, **1993**
49. Dhawan, S. Microbial deterioration of mural paintings. In *Biodeterioration of Materials - 2* Saivash R.B. et al. Eds., **2002**, pp. 95–105.
50. Pangallo, D.; Kraková, L.; Chovanová, K.; Šimonovičová, A.; De Leo, F.; Urzì, C. Analysis and comparison of the microflora isolated from fresco surface and from surrounding air environment through molecular and biodegradative assays. *World J. Microb. Biot.* **2012**, *28*, 2015–2027. DOI: 10.1007/s11274-012-1004-7
51. Pangallo, D.; Chovanová, K.; Šimonovicová, A.; De Leo, F.; Urzì, C. Assessment of the biodeterioration risk of the Ladislav legend fresco in Velka Lomnica (SK) through non-invasive methods. In Proceedings of the 11<sup>th</sup> International Congress on deterioration and conservation of stone, vol I, 15-20 September Torun, Poland; **2008**, 457–464.
52. Chaisrisook, C.; Suwanarit, P.; Aranyanak, C. Fungal deterioration of mural paintings in the royal temple. In *Biodeterioration of cultural property 3*: Proceedings of the 3<sup>rd</sup> international conference on biodeterioration of cultural property, July 4-7, 1995, Bangkok, Thailand **1995**, pp. 116–137.
53. Senbua, W.; Wichitwechkarn, J. Molecular identification of fungi colonizing art objects in Thailand and their growth inhibition by local plant extracts. *3 Biotech* **2019**, *9*, 356. DOI: 10.1007/s13205-019-1879-1
54. Crippa, A. *Funghi isolati da affreschi murali in antiche chiese di Pavia*. Atti Società Italiana Scienze Naturali Museo Civico Storia Naturale Milano **1983**, *124*: 3–10. (<https://www.biodiversitylibrary.org/item/267082#page/10/mode/1up> accessed 31/01/2022)
55. Sampò S.; Luppi Mosca A.M. A study of the fungi occurring on 15<sup>th</sup> century frescoes in Florence, Italy. *Int. biodeterior.* **1989**, *25*, 343–353. DOI:10.1016/0265-3036(89)90014-6
56. Milanesi, C.; Baldi, F.; Vignani, R.; Ciampolini, F.; Faleri, C.; Cresti, M. Fungal deterioration of medieval wall fresco determined by analysing small fragments containing copper. *Int. Biodeter. Biodegr.* **2006**, *57*, 7-13. DOI:10.1016/j.ibiod.2005.10.002
57. Jeffries, P. Biodeterioration of wall paintings in Canterbury Cathedral. In *Biodeterioration of Cultural Property*, Agrawal, O.P., Dhawan, S., Eds. Proceedings of the International Conference on Biodeterioration of Cultural Property, February 20-25, 1989. Macmillan, India (Delhi) **1991**, pp. 287–293.

58. Jeffries, P. Growth of *Beauveria alba* on mural paintings in Canterbury Cathedral. *Int. Biodeter. Biodegr.* **1986**, *22*, 11–13.
59. Jurado, V.; Gonzalez-Pimentel, J.L.; Hermosin, B.; Saiz-Jimenez, C. Biodeterioration of Salón de Reinos, Museo Nacional del Prado, Madrid, Spain. *Appl. Sci.* **2021**, *11*, 8858. DOI:10.3390/app11198858
60. Fiorillo, F.; Fiorentino, S.; Montanari, M.; Monaco, C.R.; Del Bianco, A.; Vandini, M. Learning from the past, intervening in the present: the role of conservation science in the challenging restoration of the wall painting Marriage at Cana by Luca Longhi (Ravenna, Italy). *Heritage Sci.* **2020**, *8*, 1–13. DOI: 10.1186/s40494-020-0354-y
61. Cepero, A.; Martinez, P.; Castro, J.; Sanchez, A.; Machado, J. The biodeterioration of cultural property in the republic of Cuba: A review of some experiences. In: *Biodeterioration of cultural property*, Proceedings of the 2<sup>nd</sup> international conference, October 5-8, **1992**, Yokohama, Japan, pp. 479–487.
62. Raschle, P. Experience of combating moulds during restoration of ceiling paintings in a Swiss baroque monastery church. *Biodeterioration* **1983**, *5*, 427–433.
63. Savulescu, A.; Ionita, I. Contributions to the study of the biodeterioration of the works of art and historic monuments, I. Species of fungi isolated from frescoes. *Revue roumaine de biologie* **1971**, *16*, 201–206.
64. Ionita, I. Contributions to the study of the biodeterioration of the work of art and of historic monuments. II. Species of fungi involved in the deterioration of mural paintings from the monasteries of Moldavia. *Revue Roumaine de Biol., Serie de Botanique* **1973**, *18*, 179–189.
65. Popescu, A.; Arai, H.; Minatoya, T. Biodeterioration aspects of the Probota Monastery and possibilities for its restoration. In *Biodeterioration of cultural property 3*, Proceedings of the 3<sup>rd</sup> international conference on biodeterioration of cultural property, July 4-7, 1995, Bangkok, Thailand; **1995**, pp. 255–271.
66. Gomoiu, I.; Cojoc, R.L.; Enache, M.I.; Neagu, S.E.; Mohanu, D.; Mohanu, I. Microbial ability to colonize mural painting and its substrate. *Acta Phys. Polo. A* **2018**, *134*, 383–386. DOI:10.12693/APhysPolA.134.383
67. Moza, M.I.; Mironescu, M.; Georgescu, C.; Florea, A.; Bucşa, L. Isolation and characterisation of moulds degrading mural paintings. *Annals of RSCB* **2012**, *17*, 136–142.
68. Dornieden, T.; Gorbushina, A.A.; Krumbein, W.E. Biodecay of cultural heritage as a space/time-related ecological situation—an evaluation of a series of studies. *Int. Biodeter. Biodegr.* **2000**, *46*, 261–270. DOI: 10.1016/S0964-8305(00)00107-4
69. Berner, M.; Wanner, G.; Lubitz, W. A comparative study of the fungal flora present in medieval wall paintings in the chapel of the castle Herberstein and in the parish church of St Georgen in Styria, Austria. *Int. Biodeter. Biodegr.* **1997**, *40*, 53–61. DOI: 10.1016/S0964-8305(97)00062-0
70. Sáiz-Jiménez, C.; Samson, R.A. Microorganisms and environmental pollution as deteriorating agents of the frescoes of the Monastery of "Santa María de la Rábida", Huelva, Spain, **1981**
71. Sáiz-Jiménez, C.; Samson, R.A. Biodegradacion de obras de arte. Hongos implicados en la degradacion de los frescos del monasterio de la Rabida (Huelva). *Bot. Macaronesica* **1981**, *8–9*, 255–264.
72. Tonolo, A.; Giacobini, C. Microbiological changes of frescoes. In *Recent Advances in Conservation*, Thomson, G., Ed., Butterworths, London; **1961**, pp. 62–64.
73. Guglielminetti, M.; De Giuli Morghen, C.; Radaelli, A.; Bistoni, F.; Carruba, G.; Spera, G.; Caretta, G. Mycological and Ultrastructural studies to evaluate biodeterioration of mural paintings. Detection of fungi and mites in frescos of the Monastery of St Damian in Assisi. *Int. Biodeter. Biodegr.* **1994**, *33*, 269–283. DOI:10.1016/0964-8305(94)90066-3
74. Pitzurra, L.; Bellezza, T.; Giammarioli, M.; Giraldi, M.; Sbaraglia, G.; Spera, G.; Bistoni, F. Microbial environmental monitoring of the refectory in the monastery of St. Anna in Foligno, Italy. *Aerobiologia* **1999**, *15*, 203–209. DOI:10.1023/A:1007667213499
75. Karpovich-Tate, N.; Rebrikova, N.L. Microbial communities on damaged frescoes and building materials in the cathedral of the Nativity of the Virgin in the Pafnutii-Borovskii monastery, Russia. *Int. Biodeter. Biodegr.* **1991**, *27*, 281–296. DOI: 10.1016/0265-3036(91)90057-X
76. Pepe, O.; Sannino, L.; Palomba, S.; Anastasio, M.; Blaiotta, G.; Villani, F.; Moschetti, G. Heterotrophic microorganisms in deteriorated medieval wall paintings in Southern Italian churches. *Microbiol. Res.* **2010**, *165*, 21–32. DOI: 10.1016/j.micres.2008.03.005
77. Marco, A.; Santos, S.; Caetano, J.; Pintado, M.; Vieira, E.; Moreira, P.R. Basil essential oil as an alternative to commercial biocides against fungi associated with black stains in mural painting. *Building and Environment* **2020**, *167*, 106459. DOI:10.1016/j.buildenv.2019.106459

78. Rosado, T.; Mirão, J.; Candeias, A.; Caldeira, A.T. Characterizing microbial diversity and damage in mural paintings. *Microsc. Microanal.* **2015**, *21*, 78. DOI: 10.1017/S1431927614013439
79. Rosado, T.; Mirão, J.; Candeias, A.; Caldeira, A.T. Microbial communities analysis assessed by pyrosequencing – a new approach applied to conservation state studies of mural paintings. *Anal. Bioanal. Chem.* **2014**, *406*, 887–895. DOI: 10.1007/s00216-013-7516-7
80. Rosado, T.; Gil, M.; Caldeira, A.T.; Martins, M.D.R.; Dias, C.B.; Carvalho, L.; Mirão, J.; Candeias, A.E. Material characterization and biodegradation assessment of mural paintings: Renaissance frescoes from Santo Aleixo Church, Southern Portugal. *Int. J. Architect. Heritage* **2015**, *8*, 835–852. DOI:10.1080/15583058.2012.751466
81. Martins, R.; Fialho, S.; Lima, M.; Tavares, D.; Mirão, J.; Valadas, S.; Candeias, A.E. Biodegradation assessment of a 16th century fresco from Southern Portugal. *Microsc. Microanal.* **2009**, *15*, 65–66. DOI:10.1017/S143192760999078X
82. Rosado, T.; Gil, M.; Mirão, J.; Candeias, A.; Caldeira, A.T. Oxalate biofilm formation in mural paintings due to microorganisms – A comprehensive study. *Int. Biodeter. Biodegr.* **2013**, *85*, 1–7. DOI: /10.1016/j.ibiod.2013.06.013
83. Sorlini, C.; Allievi, L.; Sacchi, M.; Ferrari, A. Microorganisms present in deteriorated materials of the Palazzo della Ragione in Milan. *Int. Biodeterior. Bull.* **1982**, *18*, 105–110.
84. Dhawan, S. Microbial deterioration of mural paintings. In *Biodeterioration of Materials* - 2 Saivash R.B. et al. Eds., **2002**, pp. 95–105.
85. Mishra, A.K.; Garg, K.L. Microbial deterioration of wall paintings. In *Biodeterioration of cultural property 3; Proceedings of the 3<sup>rd</sup> international conference on biodeterioration of cultural property*, July 4-7, 1995, Bangkok, Thailand **1995**, pp. 630–642.
86. Rebricova, N.L. Some ecological aspects of protection of old Russian wall paintings from microbiological deterioration. In *Biodeterioration of Cultural Property*, Agrawal, O.P., Dhawan, S., Eds. Macmillan, New Delhi, India; **1991**, pp. 294–306.
87. Stupar, M.; Grbić, M.L.; Simić, G.S.; Jelikić, A.; Vukojević, J.; Sabovljević, M. A sub-aerial biofilms investigation and new approach in biocide application in cultural heritage conservation: Holy Virgin Church (Gradac Monastery, Serbia). *Indoor Built Environ.* **2012**, *23*, 584–593. DOI:10.1177/1420326X12466753
88. Ripka, K. Identification of microorganisms on stone and mural paintings using molecular methods (Doctoral dissertation, University of Wien); **2005**, 148 pp. ( <http://othes.univie.ac.at/13628/1/endvers.2.pdf>, accessed 02/12/2021)
89. Rebricova, N.L. Micromycetes taking part in deterioration of old Russian wall paintings. *Recent advances in biodeterioration and biodegradation: volume 1: biodeterioration of cultural heritage*; **1993**, 205–232.
90. Gargani, G. Fungus contamination of Florence art masterpieces before and after the 1966 disaster. In: *Biodeterioration of materials, microbiological and allied aspects*; **1968**, pp. 252–257.
91. Veneranda, M.; Prieto-Taboada, N.; de Vallejuelo, S.F.O.; Maguregui, M.; Morillas, H.; Marcaida, I.; Castro, K.; Madariaga, J.M.; Osanna, M. Biodeterioration of Pompeian mural paintings: fungal colonization favoured by the presence of volcanic material residues. *Environ. Sci. Poll. Res.* **2017**, *24*, 19599–19608. DOI: 10.1007/s11356-017-9570-8
92. Bassi, M.; Giacobini, C. Scanning electron microscopy: a new technique in the study of the microbiology of works of art. *Int. Biodeter. Biodegr.* **2001**, *48*, 55–66. DOI: 10.1016/S0964-8305(01)00066-X
93. Pepe, O.; Palomba, S.; Sannino, L.; Blaiotta, G.; Ventorino, V.; Moschetti, G.; Villani, F. Characterization in the archaeological excavation site of heterotrophic bacteria and fungi of deteriorated wall painting of Herculaneum in Italy. *J. Environ. Biol.* **2011**, *32*, 241–250.
94. Sorlini, C.; Sacchi, M.; Ferrari, A. Microbiological deterioration of Gambara's frescoes exposed to open air in Brescia, Italy. *Int. Biodeter.* **1987**, *23*, 167–179. DOI:10.1016/0265-3036(87)90052-2
95. Zucconi, L.; Gagliardi, M.; Isola, D.; Onofri, S.; Andaloro, M.C.; Pelosi, C.; Pogliani, C.; Selbmann, L. Biodeterioration agents dwelling in or on the wall paintings of the Holy Saviour's cave (Vallerano, Italy). *Int. Biodeter. Biodegr.* **2012**, *70*, 40–46. DOI:10.1016/j.ibiod.2011.11.018
96. Caneva, G.; Tescari, M.; Bartoli, F.; Nugari, M.P.; Pietrini, A.M.; Salvadori, O. Ecological mapping for the preventive conservation of prehistoric mural paintings in rock habitats: the site of Filiano (Basilicata, Italy). *Conserv. Sci. Cult. Herit.* **2015**, *15*, 53–59. DOI: 10.6092/issn.1973-9494/7118
97. Unković, N.; Grbić, M.L.; Stupar, M.; Savković, Ž.; Jelikić, A.; Stanojević, D.; Vukojević, J. Fungal-induced deterioration of mural paintings: in situ and mock-model microscopy analyses. *Microsc. Microanal.* **2016**, *22*, 410–421. DOI: 10.1017/S1431927616000544

98. Unković, N.; Dimkić, I.; Stupar, M.; Stanković, S.; Vukojević, J.; Ljaljević Grbić, M. Biodegradative potential of fungal isolates from sacral ambient: in vitro study as risk assessment implication for the conservation of wall paintings. *PlosOne* **2018**, *13*, e0190922. DOI:10.1371/journal.pone.0190922
99. Unković, N.; Ljaljević Grbić, M.; Subakov-Simić, G.; Stupar, M.; Vukojević, J.; Jelikić, A.; Stanojević, D. Biodeteriogenic and toxigenic agents on 17<sup>th</sup> century mural paintings and facade of the old church of the Holy Ascension (Veliki Krčimir, Serbia). *Indoor and Built Environ.* **2015**, *25*, 826–837. DOI: 10.1177/1420326X15587178
100. Unković, N.; Erić, S.; Šarić, K.; Stupar, M.; Savković, Ž.; Stanković, S.; Stanojević, O.; Dimkić, I.; Vukojević, J.; Ljaljević Grbić, M.; Biogenesis of secondary mycogenic minerals related to wall paintings deterioration process. *Micron* **2017**, *100*, 1–9. DOI: 10.1016/j.micron.2017.04.004