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Editorial

New Insights into Earthen Site Conservation: Multidisciplinary Collaboration and Development

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Earthen sites are ancient sites that hold significant historical, cultural, and scientific value, with earth serving as the primary building material [1–3]. As places of great importance for civilization, earthen sites not only account for a large proportion of cultural heritage resources but also contain extremely rich historical information. They form an important basis for studying the origin and development of civilization and have great historical, scientific, and artistic value. Taking China as an example, earthen sites are distributed throughout the country [4]; as of the confirmation of the sixth batch of national key cultural relic protection sites, there are about 400 earthen sites on this list, distributed over 30 provinces (municipalities and autonomous regions) across the country. Their construction technology includes adobe, rammed earth, cast earth, and other methods, and their construction methods mainly include raw earth excavation, silt ramming, adobe masonry, wet earth, and mud pile construction [5–7]. These sites include ancient cities (such as the rammed-earth ancient city wall of Pingyao, Shanxi), the Great Wall, passes, beacons, earth towers (such as the Yumen Pass earthen site), tombs (such as the Western Xia royal tombs), earth pits, earth caves, earth kilns, earth cellars (such as the Qin Shihuang Terracotta Warriors and Horses Earth Pit), and rammed-earth buildings (such as the Hakka earth buildings in Fujian).

However, due to the multiple influences of environmental factors, microbial activity, and physical wear, the surface corrosion problem of earthen sites is becoming increasingly serious [8]. Irreversible damage constantly erodes their historical and archeological value. The protection of earthen sites urgently requires interdisciplinary innovative ideas and technological breakthroughs. The protection of earthen sites has developed into a multidisciplinary field combining physics, chemistry, archeology, geology, humanities, and art [9–12]. Relevant research fields encompass protection concepts, value interpretation, disease mechanisms, protection technologies, preventive protection, and the digitization of cultural relics. As a result, numerous excellent scientific research results have been obtained.

Against this backdrop, we organized and launched a Special Issue titled New Insights into Earthen Site Conservation: Methods, Techniques, Management, and Key Case Studies (https://www.mdpi.com/journal/coatings/special_issues/IK22749J11, accessed on 24 October 2025). In early research progress, Xiao and other scholars reviewed the technological evolution of earthen site surface protection from 2000 to 2025 [13]. They believed that with the deep integration of digital twin technology, spatial information technology, intelligent systems, and sustainable concepts, earthen site surface protection technology is transforming from single-point application to multi-dimensional integration. They also pointed out that the development of surface protection technology for earthen sites has gone through three stages: from early point-based monitoring technologies such as remote

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sensing (RS) and the Global Positioning System (GPS) to spatial modeling technologies such as Laser Detection and Ranging (LiDAR) and Geographic Information Systems (GIS), and finally to today's integrated intelligent monitoring systems based on multi-source fusion. Key surface technology systems include GIS-based spatial data management, high-precision modeling based on LiDAR, 3D reconstruction based on oblique photography, and Building Information Modeling (BIM) for structural protection. Cutting-edge areas focus on digital twins (DT) and the Internet of Things (IoT) for intelligent monitoring, augmented reality (AR) for immersive visualization, and blockchain technology for digital authentication. Future research on surface protection technologies for earthen sites is expected to integrate big data and cloud computing to achieve multidimensional predictions of surface degradation. Virtual reality (VR) will overcome spatial and temporal constraints and advance the conservation paradigm towards automation, intelligence, and sustainability.

These are all areas that deserve our in-depth attention and future research. The implementation of multidisciplinary collaborative innovation and practical application in earthen site conservation requires mechanisms as a foundation, technology as a core, practice as a guide, and international cooperation as a catalyst. Only by breaking down disciplinary barriers, overcoming technical bottlenecks, adapting to regional needs, and sharing global experience can we achieve the long-term protection of earthen sites. These heritage sites, carrying millennia of civilization, can be revitalized through scientific conservation and become a cultural link connecting the past and the future.

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