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CHINA-PORTUGAL BELT AND ROAD JOINT LABORATORY
ON CULTURAL HERITAGE CONSERVATION SCIENCE

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前沿研究 Research Fronts

现代教育建筑的适应性再利用和可持续保护

Adaptive Reuse and Sustainable Conservation for Modern Educational Architecture

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1. 引言

教育建筑创造了一种新的在世界范围内得到广泛应用的布局类型。新的教学方法和改进的教学理念体现在学校建筑布局中, 学习环境从单一房间转变为线性教室。随着各国社会服务的发展, 这些教室提供的教学和活动符合联合国教科文组织的教育要求。希勒认为这类学校建筑得益于现代建筑引入了功能主义方法, 这对于理性至关重要。希勒的著作中关注了 120 多所现代学校, 用以阐释社会经济需求、生态限制和物质发展。这种专门建造的教育建筑至今仍在使用。它们不仅具有重要的教育价值, 也为建筑史做出了重要贡献。

学校建筑的破败现状已无法满足现代学习的硬件要求, 其空间也难以适应 21 世纪的教育模式。现代教育建筑适配了教学方法, 并注重自然采光、通风和环境友好等因素, 以创造功能齐全的空间, 但气候变化和创新教学方法的出现, 仍要求学校进行进一步的改造。

从历史角度来看, 某些现代教育建筑对文化和社会规范产生了显著影响。这些地标性建筑不仅是物质象征, 还在保障国家福祉、传递社会政治诉求以及推动国家现代历史发展方面发挥了重要作用。这凸显了现代教育建筑作为学习的物质空间以及体现有形和无形价值的场所的重要性。因此, 本文要探讨的关键问题是:

1. Introduction

Educational architecture, created a new school layout typology that has been extensively used worldwide. New teaching approaches and improved pedagogy were reflected in school building layouts, which changed learning settings from one room to linear classrooms. With the development of nations' social services, these classrooms provided teaching and activities that followed the United Nations Educational, Scientific and Cultural Organisation's (UNESCO) pedagogical requirements. Modern Architecture introduced the functionalist approach, which was crucial to rationality, at the same time as this sort of school building Hille. More than 120 modern schools were used in Hille's book to illustrate society's social and economic requirements, ecological restrictions, and material growth. This purpose-built educational architecture is still in use. Its status is valuable for educational purposes, as well as for presenting a significant contribution to architectural history.

The decaying architecture of schools lacks the physical requirements for contemporary learning. Its spaces are inadequate for 21st-century schooling. Modern educational architecture met teaching methods and created functional spaces with environmental considerations like natural light, cross ventilation, and friendliness, but climate change and innovative pedagogical approaches require further changes.

From a historical standpoint, several of these modern educational buildings

对于作为历史建筑或文化遗产的校园建筑, 应采取哪些保护策略, 使其既能满足当代教育体系的需求, 又能确保其真实性, 并融入现代价值观, 从而创造适宜的新型学习环境。

2. 适应性再利用概念

适应性再利用是目前最受欢迎的保护策略之一, 它为现有的历史建筑赋予新的用途, 确保其在可预见的未来得以保存。普莱沃茨和克雷姆普勒指出, 适应和再利用的概念构成了适应性再利用的基础。他们解释说, 该词特指对建筑功能和物质结构进行改造。这使得在保留其历史重要元素的同时, 也能对建筑的功能进行调整。由于改造旧建筑而非建造新建筑, 可以减轻地球资源的压力, 因此保护和可持续性成为了同义词。

历史建筑的适应性再利用是一种管理文化遗产地的方法, 它赋予了现有文化新的意义。这意味着现有建筑既具有历史意义, 又具有建筑价值。因此, 改造的程度尚无定论, 涵盖了从建筑外观的大幅改造到仅限于内部的细微改动等多种形式。虽然最初的影响可能并不明显, 但用途的改变最终会导致建筑的显著变化。一些在现代时期建造的建筑, 例如教育机构, 仍然沿用其最初的用途, 而另一些建筑则经历了重大转变。由于设计过时、功能有限, 且无法满足数字时代快速信息交流的需求, 这些建筑往往难以满足当代的需求。

根据普莱沃茨和克雷姆普勒的观点, 历史建筑适应性再利用的基本原则包括真实性、美学吸引力和建筑年代。伯克和格罗夫纳则认为, 学校固有的共同记忆、对周边环境的显著影响以及重要的历史意义, 使其备受尊重。因此, 保护这些建筑至关重要, 不仅因为它们作为教育空间的实用功能, 更因为它们超越了最初的用途, 具有重要的历史和文化价值。

另一方面, 在过去十年中, 可持续性一直是建筑和城市规划领域的热门话题。李渊等人指出, 应运用科学框架、程序及方法来指导适应性再利用, 因为这一概念以可持续性为导向。

have had a notable influence on cultural and social norms. These landmarks not only served as physical symbols but also played a role in providing for the nation's welfare, transmitting social and political demands, and contributing to its modern historical development. This emphasises the significance of modern educational architecture as a physical space for learning, as well as a place where both tangible and intangible values are manifested. Thus, the crucial issue to address in this paper is which conservation strategies should be undertaken for historic or heritage school buildings to align them with the demands of the present-day education system while ensuring their authenticity and incorporating modern values to create adequate new learning environments.

2. Adaptive Reuse Concept

One of the most popular preservation strategies, adaptive reuse, finds a new use for an existing historic building, ensuring it will be around for the foreseeable future. According to Plevoets and Cleempoel, the concepts of adaptation and reuse form the basis of adaptive reuse. They explained that modifications involving both functional and physical components are specifically mentioned by the word. This permits functional alterations to the building while preserving its historically significant elements. As a result of repurposing an old building rather than constructing a new one, less strain is placed on the planet's resources, which is why preservation and sustainability are synonymous.

Adaptive reuse for heritage buildings is a method of managing cultural heritage sites and introducing new significance to an existing culture. This implies that the existing structure possesses both historical significance and architectural relevance. Hence, the extent of adaptation remains unspecified, encompassing a spectrum that spans from substantial modifications to the building's exterior to minor alterations confined to the interior. While the first impact may not be immediately apparent, the change in purpose will ultimately result in substantial alteration. Certain buildings constructed throughout the modern age, such as educational institutions, continue to serve their original purposes, while others undergo significant transformations. Due to their outdated design, limited functionality, and inability to handle the rapid information exchange needed in the digital age, they often fail to meet contemporary

可持续生态系统的一个组成部分是创造性地利用现有建筑存量。对文化遗产进行可持续改造,有助于构建可持续的建筑和城市。由于综合策略涉及诸多环节,历史建筑的适应性再利用并非易事。瓦尔多普洛斯等人认为,适应性再利用是一种提升城市可持续性的方法,它有助于资源管理、促进经济发展、增强对游客的吸引力,并重新激发人们的参与感。因此,用于可持续保护的适应性再利用工具必须具有创新性,并开发出关于旧建筑改造和再利用的新思路。

3. 当代挑战

鉴于前文所述,现代学校建筑的建立旨在将教育理论与现代建筑理念相结合。当代对这些建筑的再利用强调了教育环境在支持学校学习过程和活动方面的潜力。这些教育空间不仅代表了现代有形遗产,也体现了教育过程与社会文化背景之间的无形联系。然而,有人认为,在此背景下,无论是教育政策制定者还是城市规划者,都应共同努力,管理和分担维护教育空间的责任,同时探索这些空间可以重新利用的潜在功能。鉴于此,有必要重点阐述那些被认为是教育空间适应性再利用挑战性因素的主要当代维度。

3.1. 空间组织与教学法

教育环境的空间布局及其与教学法的互动方式在激发知识获取方面发挥着重要作用。由于传统的教学过程依赖于教师在教育空间中的位置,因此教学机构的空间组织(空间和场所)采用了一种系统化的布局和城市结构,以适应教育过程。然而,在过去十年中,教育和技术的飞速发展对传统的教育方式产生了影响和挑战,这些空间变得不再适用,并且与教学实践的发展脱节。因此,在某些情况下,例如科威特的凯鲁万学校(如图1所示),这些空间正在努力调整和重新定位其空间和场所,以满足新的学习环境需求。这促使人们寻求多层次的互动,并调整现有的空间配置以应对教学挑战。

阿尔托大学图书馆大楼(如图2和图3所示)于2017年进行了修复和改造,以容纳一个满足个人和小组学习需求的媒体空间。这为

needs.

The fundamental principles of adaptive reuse practice for historic buildings, according to Plevvoets and Cleempoel, include authenticity, aesthetic appeal, and the age of the building. According to Burke and Grosvenor, school's intrinsic feeling of shared memory, the palpable impact they have on the constructed surroundings, and essential historical relevance make them highly respected. Therefore, it is important to conserve these buildings for their practical role as educational spaces, and their historical and cultural relevance, which have outlived their original purpose.

On the other hand, sustainability has been a highly discussed subject in the realm of architecture and urban planning during the past decade. Li et al. stated that scientific frameworks, procedures, and approaches should be used to guide adaptive reuse because the concept is oriented towards sustainability. One part of sustainable ecosystems is making creative use of existing building stock. Contributing to sustainable architecture and cities are sustainable adaptations of cultural heritage. Because of the various moving parts involved in an integrated strategy, adaptive reuse of historic structures is not an easy task. According to Vardopoulos et al., adaptive reuse is a method for improving urban sustainability that helps with resource management, boosting the economy, making a place more appealing to tourists, and getting people involved again. That is why adaptive reuse tools for sustainable conservation must get creative and develop new ways of thinking about and repurposing old buildings.

3. Contemporary Challenges

Considering the preceding discourse, modern school architecture was established to unite pedagogical theories with modern architectural concepts. The concept of contemporary adoption and reuse of these buildings emphasises the potential of the educational environment to support learning processes and activities in schools. It is considered that these educational spaces are not only a representation of modern tangible heritage but also the intangible relationship between the education process and the social-cultural context. However, it could be argued that within this context, various actors and stakeholders, whether in educational policy or urban planning, should work to manage



图1: 阿尔弗雷德·罗斯, 科威特鲁迈西耶凯鲁万女子中学, 1971年。该图显示了为满足教学和气候变化要求而融入初始设计的暖通空调和教室。

Figure 1. Alfred Roth, Al-Qayrawan Girl's Intermediate School, Rumaithiya, Kuwait, 1971. The image shows the HVAC ventilation and classroom that have been incorporated into the original design to address the pedagogical and climate change requirements.



图2: 阿尔托大学图书馆大楼是列入名录的现代主义建筑之一, 最近进行了修复, 以容纳媒体和开放空间, 满足个人和小组学习工作的需求。1969年, 芬兰埃斯波, 阿尔瓦·阿尔托。

Figure 2. The library building at Aalto University, one of the listed modernist buildings, was recently restored to house media and open space that matches the individual and the group study working needs. 1969, Espoo, Finland, Alvar Aalto.



图3: 阿尔托大学, 芬兰埃斯波, 1964年, 阿尔瓦·阿尔托。

Figure 3. Aalto University, Espoo, Finland, 1964, Alvar Aalto.

and share the responsibility of maintaining the conditions of education spaces while questioning the potential functions that could be re-adopted within these places. Considering this, it is essential to highlight the main contemporary dimensions that were identified as the challenging factors of the adaptive reuse of educational spaces.

3.1. Spatial Organisation and Pedagogy

The spatial layout of the education environment and how this environment interacts with teaching and pedagogy play a significant role in activating knowledge gaining. Because the traditional pedagogical process, depends on positioning the teacher within the educational space, the spatial organization (space and place) of this institution was used to apply a systematic layout and urban structure that responded to the education process. Yet, during the last decade, significant educational and technological development has impacted and challenged the traditional educational approach, where these spaces became inadequate and isolated from the development of pedagogical practices. Thus, in some cases, such as Al-Qayrawan School in Kuwait (as shown in Fig. 1), these spaces work to align and re-position their spaces and places to meet the new learning environment needs. This pushes toward seeking various layers of interactions and adapting the current spatial configurations to respond to the pedagogical challenges.

The case of the library building of Alvar Aalto University (shown in Figures 2 and 3), was restored and reshaped in 2017 to house a media space that matches the individual and the group study's working needs. This offers a new perspective to understand the spatial organization of the modernist building and take its architecture to the twentieth century while introducing a contemporary notion of the social and cultural context. Yet, spatial adaptation may encounter different challenges associated with the fragile architectural details and the limited adaptive techniques that could be applied due to the building's status whether as a listed building or due to the cultural identity of buildings within its context.

3.2. Climate Change and Sustainability Vision

The adaptive reuse of existing educational spaces and buildings is a

我们理解这座现代主义建筑的空间组织提供了一个新的视角，同时将这座二十世纪风格的建筑融入当代社会文化语境。然而，由于建筑本身的保护地位（无论是作为历史建筑还是由于其所在区域的文化特性），空间改造可能会面临诸多挑战，例如脆弱的建筑细部以及可采用的改造技术有限。

3.2. 气候变化与可持续发展愿景

对现有教育空间和建筑进行适应性再利用是一种可持续的机制，能够为现有的现代主义建筑赋予新的机遇。作为一种策略，它旨在延长被忽视的现有教育空间的使用寿命，实现环境、经济或社会遗产效益，并避免这些建筑被拆除。该策略已被广泛应用于不同功能，但它要求建筑在其所处的环境中保留独特的建筑细部、文化和遗产价值。考虑到这一点，它还应满足新的目标用户的社会期望并促进经济价值的提升。

根据奥斯曼和埃尔萨伊的观点，可持续发展原则的实现，在于功能需求可满足用户和利益相关者的视角、愿望、需求和期望，同时兼顾环境保护、社会发展和经济繁荣。因此，现代教育空间的适应性再利用将有助于夯实可持续发展的各个支柱：通过重新加强与社区遗产的社会互动，借机颂扬本土材料和建筑价值，并减少新建建筑的不必要成本。

3.3. 城市和社会同化

战后时期普遍被认为是将现代建筑融入教育环境的绝佳时期，当时空间和城市设计原则正经历着不同程度的变革，并面临着与教育政策的重大而快速的变革相关的挑战。这一时期为学术环境及其教育政策如何体现和表达现代建筑提供了非凡的方案和机遇。技术能力的运用、新型结构的开发以及新材料的使用，旨在体现这些创新方法。在此基础上，人们进一步探讨了理解这种创新环境如何促进其所处环境、地点和国家的意义。同时，也力求实现平稳过渡，既能适应当代建筑的快速变化，又能体现其社会的独特性。

为了理解这一观点，莫拉斯提出了一些具

sustainable mechanism to give new opportunities to existing modernist buildings. As a strategy, it aims to prolong the life span of the existing educational spaces that are neglected, to achieve environmental, economic, or social heritage benefits, and to prevent these buildings at the level of demolished. This strategy has been adopted widely across different functions, yet it requires that the building hold unique architectural details, cultural and heritage values within its context. Bearing this in mind, it should also satisfy the social expectations of the new targeted users and promote economic values.

According to Othman and Elsaay, sustainable principles are achieved by achieving the required functions that understand and match the users' and stakeholders' perspectives, desires, needs, and expectations while considering protecting the environment, enhancing society, and prospering the economy. Therefore, the adaptive reuse of modern educational spaces will contribute and promote the different pillars of sustainability; through re-enhancing the social interaction with the community heritage, providing an opportunity to celebrate the local materials and architectural values, in addition to reducing the unnecessary cost of structuring new buildings.

3.3. Urban and Societal Assimilation

The post-war period was generally considered the perfect chapter to embrace modern architecture in the education environment, where the spatial and urban design principles were experiencing different levels of transformations and challenges associated with the significant and rapid changes that the education policy faced. This period provides extraordinary proposals and opportunities in the way that the academic environment and its education policies reflect and express modern architecture. Mobilising technical capability, new structures, and materials intended to reflect these new innovative approaches. Within this, additional debate was raised towards understanding how this innovative environment could promote the meaning of its context, place, and nation. Bearing in mind achieving smooth transactions that would adopt the rapid changes in contemporary architecture and still reflect the individuality of its society.

To understand that Maurrasse

体内容, 这些方面有助于支持当地社区参与, 从而将教育环境与城市连接起来。首先是教育规模、教育机构的环境、机构与其环境之间的关联层次和程度、社区机构的能力和潜力、历史文化维度和结构、财政支持或资金, 最后是教育环境本身, 以及它对环境和机构创新的使命和承诺。这些方面旨在提升教育空间, 改善社区的城市品质。因此, 我们应该认识到, 已采纳的教育政策与其空间设计统一性和融入环境的感知之间存在着明显的互动关系。

在过去的几十年里, 教室、图书馆、实验室和礼堂等教育空间成为了检验建筑质量、并共同承担实现社会空间正义责任的理想平台。教学场所的主要目标是在安全协作的环境中, 营造一个具有自身特色和身份的学术空间。然而, 这种关系的边界可能会因社会文化规范、历史背景和教育政策而有所变化, 而这些因素又会随着时间的推移而逐渐改变。因此, 改造此类空间应强调其作为适应性再利用政策重要组成部分的潜力, 以及其在自身背景和周边环境中的身份认同。

3.4. 历史价值与遗产保护

适应性再利用策略旨在复兴被视为现代遗产的现代建筑中的教育空间。这有助于重振文化认同, 保护教育场所的建筑价值, 增强文化真实性, 并促进空间公平。

建筑遗产的历史价值是民族自豪感的重要组成部分。适应性再利用不仅能改变历史建筑的周边环境, 还能为人们提供新的参观途径。它有助于实现资金自给自足, 赋予建筑新的功能, 并根据建筑的新形象来保护遗产。然而, 这一策略需要特别关注建筑的结构完整性和建筑规范, 以及这些规范是否符合安全标准。

4. 交流建设性策略

为了贯彻可持续保护和适应性再利用的原则, 有必要考察不同地区的个案。尽管现代教育建筑在设计原则和标准上存在相似之处, 但不同地区之间仍存在差异。幼儿园、小学、初中、高中和大学都服务于教育目的; 然而, 它们在设计者、所用材料和技术、地域、气候、教学

suggests specific aspects that can help and support the local community engagement in the process of connecting the education environment and the city. First the scale of the education environment as an institution, the level and the degree of the relationship between the institution and its context, the capacity and the potential of the community-based institutions, the history the culture dimensions and structure, the financial support, or funds of the institution, and finally, the education environment, its mission and commitment towards both its context and institutional innovation. These aspects are suggested to enhance the educational space and improve the urban quality of its community. Thus, we should acknowledge that there is a clear interaction between the adopted education policy and the perception of its spatial design unity and integration within its context.

During the last decades, educational spaces, such as classrooms, libraries, laboratories, and halls were the perfect platform to validate the quality of architecture and share the responsibility towards achieving social spatial justice. Pedagogy place's main aim is to generate an intellectual place that has its character and identity within a collaborative safe environment. Yet, determining the borders of this relationship could vary according to the social-cultural norms, the historical context, and the education policy which might be gradually shifted or altered across time. Thus, adapting this space should emphasize the potential of the place as a vital aspect of adaptive reuse policy, and its identity within its context and surrounding environment.

3.4. Historical Values and Heritage Preservation

Adaptive reuse as a strategy is focused on reviving the educational spaces of modern architecture which are considered as a modern heritage. This helps to revive the cultural identity, preserve the architectural value of educational places, enhance cultural authenticity, and promote spatial justice.

The historical values of the heritage building are an integral part of the national pride. Adaptive reuse can offer new ways to access heritage buildings in addition to transforming their surrounding context. It opens the way towards achieving self-sufficient funding, new functions, and

需求以及学生的年龄和性别等方面都存在差异。此外，由于各种政策和指导方针的影响，建筑物随着时间的推移而不断改造，每个案例都呈现出不同的变化。因此，在每个案例中采用适应性再利用实践能够拓宽我们的理解，促进跨越国界和文化界限的知识和经验交流。

5. 结论

本文提出了关于评估方法、教学和气候变化要求以及适应性再利用实践方法的若干普遍关注的问题。在第十八届国际现代主义运动记录与保护国际组织会议上，围绕适应性再利用在创建更可持续的教育建筑环境中的作用展开的讨论，将揭示涉及全球教育建筑保护、修复、重建和改造的治理技术。这为文物保护人员提供了一个绝佳的机会，让他们能够合作并分享知识、理论、方法和要求，从而取得一项能够满足各种专业知识的统一而重要的成果。

utilizing heritage preservation according to the new image of the building. Yet, this strategy requires special attention to the structural integrity and building codes, and whether these codes meet the safety measures or not.

4. Exchanging Constructive Strategies

For sustainable conservation and adaptive reuse implementation principles, it is necessary to examine each case from various regions. Even though modern educational architecture shares similarities in its principles of design and standards, it differs from one region to another. Kindergartens, primary, intermediate, secondary, and universities all serve the purpose of education; however, they differ in terms of the designer, materials and technology used, the region, climate, pedagogical requirements, and the age and gender of the students. Additionally, buildings have undergone modifications over time because of the various policies and guidelines that have revealed distinct alterations in each instance. Consequently, adopting adaptive re-use practices in each instance broadens our comprehension, enabling the exchange of knowledge and expertise across national and cultural boundaries.

5. Conclusion

The paper has brought several general concerns about assessment approaches, pedagogical and climate change requirements, and adaptive reuse practice methods. At the 18th International Docomomo Conference, discussions around the role of adaptive reuse in creating a more sustainable educational built environment will reveal treatment techniques that involve preserving, rehabilitating, restoring, and reconstructing educational architecture worldwide. This presents an excellent chance for conservators to collaborate and share their knowledge, theories, methods, and requirements to achieve a unified and significant outcome that caters to a diverse range of expertise.

实践案例 Case Study

形式背后的理念：布拉迪斯拉发实验学校被忽视的特质

Ideas Behind the Form: Overlooked Qualities of the Experimental School in Bratislava

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1. 引言

二战后捷克斯洛伐克重新统一, 但两次世界大战之间的民主政权被苏联控制的极权政权所取代。政治经济形势的变化自然反映在建筑业中——不仅体现在其追求的目标上, 也体现在其施工的技术和材料能力上, 而标准化和预制化则成为其节约成本的重要手段。效仿苏联, 捷克斯洛伐克制定了五年国民经济发展计划, 旨在帮助这个饱受战争蹂躏的国家实现有效发展。所有这些都体现在战后严重短缺的学校建筑的建设中, 而新社会主义国家的重要优先事项之一是如 1948 年的《学校法》所倡导的那样确保人人享有平等的教育和教学条件。因此, 自 1950 年以来, 标准化成为大规模生产预制建筑构件的主要手段, 以提高建筑量、减少劳动力并加快施工速度。这也意味着学校建筑布局 and 结构类型在 3 到 5 年内保持稳定, 这限制了建筑师灵活应对新进展的可能性。

然而, 原型建筑提供了一种解决方案, 它允许根据研究机构、大学或国家设计部门提出的实验项目, 统一应用特定类型设计一定比例的学校。尽管这些实验项目允许建筑师从教育、建筑或结构等不同角度进行测试, 但由于它们是原型, 因此在某些方面, 建筑的质量可能较低。本文旨在通过布拉迪斯拉发 (现斯洛伐克) 一所实验学校的具体案例, 说明了解前捷克斯

1. Introduction

Czechoslovakia was reunited after World War II, but the interwar democratic regime was replaced by a totalitarian one, subordinate to the Soviet Union. The changed political and economic situation was naturally reflected in the building industry – in the goals it pursued, but also in the technical and material possibilities of construction, while typification and prefabrication became important tools of its economisation. Following the example of the USSR, five-year plans for the development of the national economy were intended to help the effective development of the war-torn country. All this was also reflected in the construction of school buildings, of which there was a shortage after the war, while one of the important priorities of the new socialist state was to enable equal conditions of education and teaching for all as advocated by the School Law from 1948. Therefore, since 1950, typification became the main tool for the mass production of building prefabricated building elements, to increase the volume of construction, reduce labour and speed up construction time. This also meant that the school building layouts and structural types were stabilised for 3 to 5 years which limited the architects' possibility of responding flexibly to new progress.

However, some solution was offered by a prototype construction, which allowed, along with the otherwise consistent application of a particular school type, to design a certain percentage of schools according to experimental projects proposed by research and study institutes, universities

洛伐克实验学校的建造背景和条件对于提出恰当的当代改造方案至关重要。对历史背景的无知可能导致对建筑意义的错误评估，从而导致不恰当的建筑改造。

尽管本文旨在凸显建筑师弗拉基米尔·卡尔菲克 (Vladimír Karfík, 1901–1996) 和土木工程师约瑟夫·哈尔万奇克 (Jozef Harvančík, 1921–1987) 设计的这所学校的贡献，但其贡献在很大程度上已被人们遗忘。本文并非试图反驳该建筑在施工上的不足，也并非试图赋予其建筑不应有的特质。然而，通过分析其所处的时代和地域的特殊性以及国际背景，本文将论证该建筑的价值在于，它是捷克斯洛伐克建筑师为数不多的重要作品之一，体现了他们对战后全球趋势的思考。本研究旨在表明，该学校的设计可以被解读为对构建一个有意识的社会的尝试，而非如官方所宣称的那样，是为了“建设社会主义”。这增加了该建筑未来得以改造的可能性，使其最初的创新特征得以恢复，尽管这些特征在历史长河中已被掩盖。

本文的论点基于建筑史研究成果，主要参考了档案资料（建筑师弗拉基米尔·卡尔菲克的个人藏品、布尔诺市博物馆）、实地考察以及当时的期刊和书籍。对卡尔菲克合著的《学校建设新方向》一书的内容分析是本文的主要研究成果。此外，本文还研究了当代关于学校建筑的文献。文章分为以下几个部分：对布拉迪斯拉发学校建筑的描述；阐明了战后时期欧洲和捷克斯洛伐克学校建设的背景；最后探讨了卡尔菲克对学校建筑的贡献，并指出在未来的学校建筑改造中应充分考虑卡尔菲克的贡献。

2. 布拉迪斯拉发实验学校

这所学校建于米耶罗瓦科洛尼亚，它是布拉迪斯拉发一家大型化工厂的住宅区之一。它是一所中学（八年制，九个班级）的原型校舍，源于斯洛伐克技术大学布拉迪斯拉发分校的研究团队于1956年在建筑师弗拉基米尔·卡尔菲克的领导下开展的一项关于预制学校建造技术的实验项目。该校舍于1957年建成，旨在测试装配系统，减少建筑材料的消耗，并从布局和运

or state design departments. Although the experimental projects permitted the architects to test different aspects from a pedagogical, architectural or structural point of view, as they were prototypes, the buildings might have been in some respects of a lower quality of execution. This paper seeks to show through the specific example of an experimental school in Bratislava (now Slovakia), that it is precisely why the knowledge of the context and conditions under which experimental schools were built in the former Czechoslovakia, is crucial in order to propose appropriate contemporary adaptations. Ignorance of the former context can lead to an incorrect assessment of the architectural significance and thus to inappropriate building interventions.

Although this paper seeks to highlight the largely forgotten contribution of the school designed by the architect Vladimír Karfík (1901–1996) and civil engineer Jozef Harvančík (1921–1987), it will not attempt to contradict the shortcomings of the building's execution or attribute unlikely qualities to the school's architecture. However, by pointing to the specifics of the time and place, as well as the international context, it will argue that the value of the building lies in the fact that it is one of the few important manifestations of the efforts of Czechoslovak architects to reflect global post-war trends. The research aims to demonstrate that the design of the school can be read as an attempt to contribute to the formation of a conscious society rather than to "building of socialism" – as it had to be officially claimed – which increases the likelihood that the building will be adapted in the future in alignment with its original innovative features that can still be restored although they have been suppressed over time.

The arguments presented in the paper are based on the results of architectural-historical research, which drew mostly from archival sources (personal fund of the architect Vladimír Karfík, Brno City Museum), site research, and period journal and book publications. Key outcomes have been obtained by a content analysis of the book *Nové směry ve výstavbě škol* (New Directions in Construction of Schools??), co-authored by Karfík. In addition, contemporary literature on the topic of school buildings has been studied. The paper is divided into the following sections: description of the school building in Bratislava itself, clarification of the context of the post-war period and the construction of schools on European scale as well as

行的角度评估采用方形平面布局和双侧自然采光的教室。(图 1)

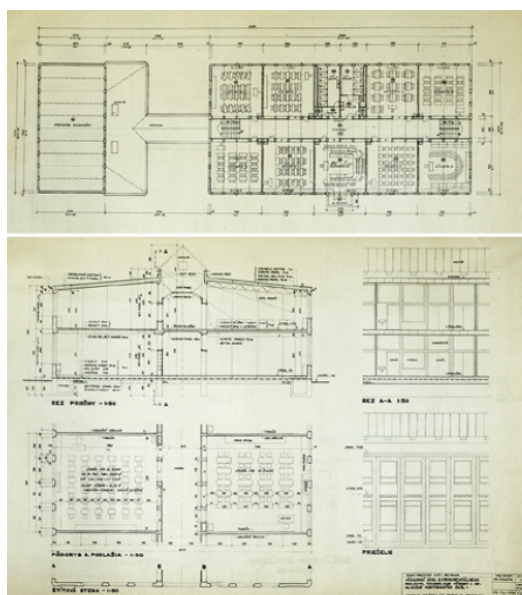


图 1: 弗拉基米尔·卡尔菲克和约瑟夫·哈尔万奇克提出的实验学校方案(1956 年), 是斯洛伐克布拉迪斯拉发技术大学开展的研究项目成果之一。

Figure 1. Vladimír Karfík and Jozef Harvančík, proposal of an experimental school (1956) as one of the results of a research project pursued at the Slovak Technical University in Bratislava.



图 2: 弗拉基米尔·卡尔菲克和约瑟夫·哈尔万奇克, 斯洛伐克布拉迪斯拉发实验学校, 1956-57 年。外观。

Figure 2. Vladimír Karfík and Jozef Harvančík, Experimental school, Bratislava, Slovakia, 1956-57. Exterior view.

尽管新的建造技术最终导致建筑成本高于传统方法, 但建筑构件的制造仅需 3 周, 主体结构 of 的组装也仅需 6 周。尽管这所学校的照片曾出现在《捷克斯洛伐克学校建设》一书的封面上, 随后又收录于《新技术与建筑》一书中, 但从建筑角度来看, 该项目并未给专业人士留下深刻印象。这一点可以从捷克斯洛伐克著名建筑杂志《建筑捷克》一位匿名编辑的简短评

in Czechoslovakia, and lastly Karfík's contribution to the topic of school buildings, awareness of which should be taken into account for future adaptations, as the paper proposes.

2. The Experimental School In Bratislava

The school in question was built in Mierová kolónia – one of the housing settlements of a large chemical plant in Bratislava. It was a prototype of a secondary (8-year, 9-class) school that emerged from the research task of an experimental project focused on the construction technology of prefabricated schools, which was solved by the research team of the Slovak Technical University in Bratislava in 1956 under the leadership of the architect Vladimír Karfík. Built in 1957, the aim was to test the assembly system, reduce the consumption of building materials, and also to evaluate the classrooms with a square floor plan and bilateral natural lighting in terms of the layout and operation of the building. (Fig. 1)

Although the new construction technology ultimately made the building more expensive than the use of a conventional one, it took only 3 weeks to manufacture the building elements and 6 weeks to assemble the building carcass. Despite the fact that the photograph of the school appeared on the cover of the publication *Výstavba škol v Československu* (Construction of Schools in Czechoslovakia) and subsequently in the book *Nova technika a architektura* (New Technology and Architecture), architecturally the project did not impress the professional public very much, as can be understood from the brief commentary by an unnamed editor of the prominent Czechoslovak architectural magazine *Architektura ČSR*, where only one page was devoted to it. Although the editor praised the progressiveness of the layout and the structural system, as well as the fact that the authors preferred square classrooms to the hitherto predominant type of classrooms with a rectangular plan, the architectural expression subordinated to the structural system did not, in his opinion, “sufficiently convey the building's purposeful mission and meaning”. (Fig. 2)

However, a more complimentary review by the architect Dušan Kuzma published in the *Projekt* magazine explains that the modular grid of the structural system was determined by the basic layout of the classroom with dimensions of 7.8 m x 7.8 m, which in turn determined the width of the

论中看出,该杂志仅用一页篇幅介绍了该项目。尽管编辑赞扬了布局和结构体系的进步性,以及设计者选择方形教室而非当时盛行的矩形教室的做法,但他认为,这种服从于结构体系的建筑表现形式“并没有充分传达建筑的用途和意义”。(图2)

然而,建筑师杜尚·库兹马在《项目》杂志上发表的一篇更为赞赏的评论解释说,该结构系统的模块化网格是由7.8米×7.8米的教室基本布局决定的,而教室的基本布局又决定了由膨胀粘土混凝土制成的墙板的宽度(195厘米)。设计者在设计时也考虑到了墙板的重量,以便于运输和安装。库兹马更详细地描述了室内特征,指出尽管建筑外观的设计并不十分引人注目,但设计者却致力于营造高质量的学习环境。钢筋混凝土构件的箱形结构使得墙体内可以嵌入橱柜和玻璃展示柜,从而与走廊空间形成视觉联系(图3)。为了保证学生身体健康,设计者在窗户下方安装了与供暖系统相连的强制通风装置。

学校和教室原有的高品质空间布局体现在该建筑至今仍用于学校用途——它于2004年被华德福学校签下30年租约。尽管该建筑继续发挥学校功能,且原有的空间理念无需进行大规模改造即可满足当前需求,这无疑是件好事,但这种改造却完全无视了原有理念的精髓。



图3: 弗拉基米尔·卡尔菲克和约瑟夫·哈尔万奇克, 斯洛伐克布拉迪斯拉发实验学校, 1956-57年。双面采光教室内部, 玻璃墙板可与走廊建立视觉联系。
Figure 3. Vladimír Karfík and Jozef Harvančík, Experimental school, Bratislava, Slovakia, 1956-57. Interior of the bilaterally lit classroom with a glazed wall panel allowing a visual connection from the classroom to the hallway.

wall panel (195 cm) made of expanded clay concrete, in which the authors also took into account its weight to allow easier transport and installation. Kuzma describes the interior features in more detail, suggesting that despite the less convincing architectural expression of the building's exterior, the authors took care to create a quality learning environment. The box-like form of the reinforced concrete parts allowed for built-in cabinets and glass display cases to be built into the wall, allowing for a visual connection to the corridor space (Fig. 3). Physical well-being of students was to be aided by forced ventilation provided by equipment connected to the heating by means of units located under the windows.

The quality of the original spatial layout of the school and classrooms is evidenced by the fact that the building has not ceased to serve the school function – the building was acquired on a 30-year lease in 2004 by the Waldorf School. Although it can be seen as positive that the building remains to serve the school function, and the original spatial concept has proved to be suitable for the current use without necessity of major construction interventions, the adaptation shows a complete ignorance of the quality of the original concept.

3. Political And Historical Context

Only by understanding the historical and political context – in Europe as well as in Czechoslovakia – is it possible to become more aware of the importance of the school for the local architectural discourse. The period after the end of World War II was characterised by efforts to rebuild wartorn Europe. Among the public facilities that the European governments were interested to invest in, education played an important role. For Western European countries (primarily Denmark, Norway and Sweden, but also the UK and France) education was a means to build a social democratic infrastructure, while for post-fascist states – such as Italy – focus on young children offered an opportunity to “build democracy and long-term resistance to fascism,” as Ian Grosvenor and Catherine Burke stress in their book *School*. In Germany, architect Hans Scharoun experimented with ideas for appropriate school design in line with contemporary international concerns for child-centred education and the strengthening of democratic society.

At the same time, several countries faced a shortage of school buildings in the

3. 政治和历史背景

只有理解历史和政治背景——无论是在欧洲还是在捷克斯洛伐克——才能更深刻地认识到学校在当地建筑话语中的重要性。二战结束后, 欧洲各国致力于重建饱受战争蹂躏的家园。在欧洲各国政府热衷投资的公共设施中, 教育扮演着重要的角色。对于西欧国家 (主要是丹麦、挪威和瑞典, 也包括英国和法国) 而言, 教育是构建社会民主基础设施的手段; 而对于意大利等后法西斯国家来说, 关注幼儿教育则提供了一个“建设民主和长期抵抗法西斯主义”的机会, 正如伊恩·格罗夫纳和凯瑟琳·伯克在他们的著作《学校》中所强调的那样。在德国, 建筑师汉斯·夏隆尝试设计的学校符合当时国际社会对以儿童为中心的教育和强化民主社会的关注。

与此同时, 20 世纪初, 一些国家面临校舍短缺的问题, 新建学校成为通过创造合适的空间来支持新的教育理念的契机。专家和教育工作者开始将校舍视为“第三位老师”, 因为人们期望学校的设计和能够体现“民主平等社会”的理念, 在这个社会中, 年轻人作为个体将受到尊重, 他们的能力将得到支持, “幼儿园、小学、社区学校和大学”将成为消除社会不平等的场所。1958 年, 国际建筑师协会在摩洛哥拉巴特组织召开了一次会议, 其学校建筑委员会讨论了新校舍的形式问题。来自多个欧洲国家 (荷兰、捷克斯洛伐克、英国、瑞典、法国、德国, 均为委员会成员国) 的代表出席了会议。

这次会议促成了《学校建筑宪章》的起草, 该宪章经修订后于 1959 年出版。该宪章的目的是为学校建筑制定基本原则, 使其能够适应各个国家的具体情况, 因为“问题的多样性、人文、经济和地理条件的差异以及教学和建筑技术的快速发展”使得“制定建筑物的尺寸或类型标准”成为不可能。尽管冷战使欧洲四分五裂, 但在摩洛哥拉巴特举行的国际建筑师协会会议上, 捷克斯洛伐克建筑师贝德里赫·施拉尼尔代表捷克斯洛伐克出席, 与会代表还包括西方国家的代表。1959 年, 《捷克斯洛伐克建筑》

early part of the 20th century, and the construction of new schools became an opportunity to support new concepts of education by creating appropriate spaces. Experts and educators alike began to think of the school building as a “third teacher,” as schools were expected to fulfil through their design and organisation the notions of a “democratic and egalitarian society,” where young people as individuals would be respected, supported in their abilities, and “[n]ursery schools, elementary schools, community schools, and colleges” would become places where societal inequalities could be eliminated. The form of new school buildings was also discussed within the framework of the Commission on School Buildings of the International Union of Architects (UIA) at a meeting organised by the UIA in 1958 in Rabat, Morocco, attended by representatives of several European countries (the Netherlands, Czechoslovakia, Great Britain, Sweden, France, Germany are all the member countries of the Commission).

The meeting prompted the drafting of the Charte des Constructions Scolaires (School building charter), which, after rectification, was published in 1959. The aim of the Charter was to set out basic principles for school buildings that can be adapted to the specific conditions of individual countries, as the “diversity of problems, the variety of human, economic and geographical conditions, and the rapid development of teaching and construction techniques” did not allow “to develop standards for the dimensions or types of buildings”. Although Europe was divided by the Cold War, the UIA meeting in Rabat, Morocco, was attended by architect Bedřich Schráníl on behalf of Czechoslovakia, in addition to representatives of Western countries, and the Charter was published in full in the journal Architektura ČSR in 1959. It may seem paradoxical that Czechoslovakia, as an Eastern Bloc country, was keen to follow the Charter, since Western countries saw in the schools the potential to strengthen democracy according to the Western model, which was undoubtedly not the goal in the countries under the Soviet Union. But the situation was a little more complex as following section shows.

4. Karfik 's Contribution To School Buildings

The interest in Western trends most likely reflected attitudes of those architects,

杂志全文刊登了该宪章。捷克斯洛伐克作为东欧集团国家，却热衷于遵循该宪章，这似乎有些矛盾，因为西方国家认为捷克斯洛伐克的学校具备按照西方模式加强民主的潜力，而这无疑并非苏联加盟共和国的目标。但正如以下章节所述，实际情况更为复杂。

4. 卡尔菲克对学校建筑的贡献

对西方潮流的兴趣很可能反映了那些建筑师的态度，他们仍然受到两次世界大战之间捷克斯洛伐克民主思想的影响。从今天的角度来看，我们有时很难清楚地区分建筑师自身的创作意图和政权对他们的控制。正如建筑史学家维罗妮卡·希特曼诺娃·罗洛娃所指出的那样，“左翼建筑师即使身处两次世界大战之间的捷克斯洛伐克，也会从更广阔的社会视角看待他们的职业。”但即使是立场中立的建筑师——卡尔菲克就是其中之一——也希望通过他们的作品为社会进步做出贡献。

教育专家卡雷尔·拉布特卡 1961 年发表的文章评价了捷克斯洛伐克战后的学校建筑，文章指出，根据 1948 年的法律，“为应用社会主义教育原则创造了条件”。然而，建筑师们发表的文章表明，他们对西方的相关讨论非常感兴趣，并从中汲取了许多灵感。因此，尽管该法律提倡以教师而非学生为中心的教育方法——这也意味着教室通常采用矩形布局——但建筑师们并不排斥尝试更“民主”的方形教室平面布局。



图4：弗拉基米尔·卡尔菲克、斯维特拉·卡尔菲科娃和马里安·马尔钦卡合著的《学校建设新方向》一书的封面。
Figure 4. Cover of the book *Nove smery vo vystavbe skol* by Vladimir Karfik, Světa Karfikova and Marian Marcinka.

who were still influenced by the ideas of interwar democratic Czechoslovakia. From today's point of view, it is not always possible to clearly distinguish between what the architects themselves tended to achieve, and what the regime forced them to do. As architecture historian Veronika Hittmanová Rollová points out, "Left-wing oriented architects had [...] considered their profession in a wider social perspective even in interwar Czechoslovakia." But even neutrally oriented architects – among whom Karfík can be counted – were interested in contributing to progress with their work.

Whereas the article by education expert Karel J. Laboutka from 1961 evaluating the post-war school buildings in Czechoslovakia states that according to the 1948 law "conditions were created for the application of the principles of socialist pedagogy", the published texts of the architects show that they were keenly interested in the debate in the West and were inspired by many examples from there. So, while the law promoted a teacher- rather than a student-centred approach in the educational process – which also meant preference of the rectangular shape of the classrooms among other things – architects were not reluctant to test more "democratic" square floor plan classrooms.

Regarding Karfík, and the co-authors of the book *Nove smery vo vystavbe skol* (Fig. 4), architects Světa Karfikova and Marián Marcinka, it is obvious that in order for the book to pass the censorship, it was not possible to completely omit the obligatory passages characterised by their socialist rhetoric and references to Soviet models. But a closer analysis of the text of the book shows that the authors not only refer to the objectives of the UIA Charter, but also to principles that are more in line with trends in the West. One of them is the square floor plan used in the experimental school in Mierová kolónia. Also, the book's bibliography mentions a number of Western, even U.S. publications.

An interesting finding comes from the analysis of the image material: 65% of the total number of images officially refer to Western school projects in Europe (mostly from Switzerland, Denmark, Sweden, France and also Great Britain), but also the U.S.A. The percentage would likely be higher because the captions for several of the images, which are reminiscent of schools in

卡尔菲克以及《学校建设新方向》(图4)一书的合著者——建筑师斯维特拉·卡尔菲科娃和马里安·马尔钦卡, 显然为了使该书通过审查, 不可能完全删除那些充斥着社会主义言论和对苏联模式引用的必要段落。但对书稿的深入分析表明, 作者不仅提及了国际建筑师协会宪章的目标, 还提及了一些更符合西方趋势的原则。其中之一便是米耶罗瓦科洛尼亚实验学校所采用的方形平面布局。此外, 该书的参考文献中还引用了一些西方, 甚至美国的出版物。

对图像素材的分析得出了一个有趣的发现: 65% 的图像标注为欧洲的西方学校项目 (主要来自瑞士、丹麦、瑞典、法国以及英国), 也包括美国的学校。由于一些图像的说明文字 (这些图像让人联想到西方学校) 没有注明具体地点, 因此实际比例可能更高。建筑师弗拉基米尔·德德切克在对该出版物的评论中强调了作者对“学校的基本单元——教室, 包括其形状、大小和家具”的关注, 并指出“空间家具的多样性是教学过程中一个重要的心理因素”。

建筑师们关注的是教室空间的品质而非建筑的外观, 这充分体现了卡尔菲克战后作品的整体风格, 即专注于建筑的功能性和技术性问题。这或许也是这座建筑——它曾启发了布尔诺 18 区多个学校项目——在过去几十年里逐渐被人遗忘的原因。迫使卡尔菲克和其他建筑师放弃在自己事务所进行设计的极权政权, 既不容忍他的美国经历, 也不容忍他曾为资本家巴塔集团工作的历史。不过他战后的职业重心使他为共产主义政权所接受, 他在 1956 年因其在进步建筑领域的贡献而荣获国家奖, 与此同时, 作为一名教育家, 他仍然是学生与西方思想之间重要的桥梁。

5. 结论

尽管对米耶罗瓦科洛尼亚实验学校的改造可能并不被视为一个特别问题——这些改造是可逆的, 而且原建筑本身也存在缺陷, 但这种情况凸显了一个问题: 不仅公众, 就连建筑师

the West, lack an indication of location. In his review of the publication, architect Vladimír Dedeček highlights the attention paid by the authors to the “basic unit of the school, the classroom, its shape, size and furnishings”, where the “variability of the furnishing of the space is emphasised as an important psychological component of the pedagogical process”.

The fact that the architects' focus is on the quality of the classroom space and not on the exterior expression of the building is very much representative of Karfík's overall post-war work, where he concentrates on the functional and technical issues of architecture. This is probably why the building, which inspired several school projects in Brno¹⁸, largely fell into oblivion in the past decades. The totalitarian regime that forced Karfík, like other architects, to give up designing in his own office, was not tolerant of either his American experience or his history of working for the capitalist Baťa. While his postwar professional focus made him acceptable to the communist regime, in 1956 he was even awarded a state prize for his work in the field of progressive building construction; at the same time, as an educator he remained a valued liaison between students and the ideas from the Western world.

5. Conclusion

Although the interventions in the experimental school in Mierová kolónia may not be perceived as particularly problematic – they are reversible and the original construction had its shortcomings; this situation highlights a problem that not only the wider public, but also the architects themselves lack sufficient insight and awareness of the work of their predecessors from the relatively recent past. This was confirmed a few years ago when a member of the international jury of an important Slovak architecture prize CE·ZA·AR 2019, attempted to highlight the qualities of an awarded project – adaptation of a school from 1970s – by criticising the original work as “soulless” and “gloomy”, typical for architecture built in the period of socialism. One of the older generation of architects, Imrich Ehrenberger (1939), reacted to the situation with justified indignation by publishing a personal reflection, which drew attention to the problem of simplistic interpretation of history and evaluation of works.

自身也缺乏对前辈们在相对较近的时期所作作品的足够了解和认识。几年前，一位斯洛伐克重要建筑奖的国际评审团成员就曾试图通过批评一座 20 世纪 70 年代学校的改造项目的原建筑“缺乏灵魂”和“阴郁”，将其视为社会主义时期建筑的典型特征，来凸显获奖项目的优点。老一辈建筑师伊姆里希·埃伦伯格（1939 年生）对此表示愤慨，并发表了一篇个人反思文章，指出历史解读和作品评价过于简单化的问题。

类似的案例表明，社会主义时期的学校建筑往往被迅速且不公平地低估。实验性项目在这方面尤其脆弱，因为它们是原型，可能并未被复制。仅凭外观，而不加深入考察和了解其历史背景，可能无法充分展现其整体建筑价值。同时，建筑质量较低并不意味着在改造时无需采取负责任的态度。布拉迪斯拉发实验学校的现状完全掩盖了其设计者的独特创意，正是基于此，才凸显了在研究中应关注其诞生背景的重要性。

Similar situations show that school buildings from the socialist period are often quickly and unjustifiably undervalued. Experimental projects are even more vulnerable in this respect, as they are prototypes that may not have been repeated. Their appearance alone, without closer examination and knowledge of the context, may not speak clearly enough about their overall architectural values. At the same time, a lower quality of construction does not mean that a building does not deserve a responsible approach when adapted. It is the knowledge of the context of the experimental school in Bratislava, whose current state has completely obscured the unique creative efforts of its authors, that points to the importance of paying attention in research to the context that led to its emergence.

平台动态 Platform Dynamics

基于光谱学和化学计量学分析的四部十六世纪葡萄牙 曼努埃尔风格泥金装饰宪章的比较研究

The comparative study of four Portuguese sixteenth-century illuminated Manueline Charters based on spectroscopy and chemometrics analysis

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1. 引言

十六世纪, 葡萄牙国王曼努埃尔一世 (1469 - 1521) 对王国下辖各城市与村庄的宪章进行了重要改革。据信, 在十六世纪最初二十年的短暂时期内, 共制作了约 580 至 600 份曼努埃尔风格宪章。尽管宪章文本的内容由王国当局主管负责, 但宪章的制作 (尤其是泥金装饰) 则由地方城镇提供财政支持。从这个意义上说, 对这些泥金装饰手抄本所用材料及绘画技术的比较研究, 能够有力地反映每个城市或村庄在制作时期的文化、政治及财政能力。根据 Garcia 的研究, 曼努埃尔风格宪章的卷首插画中, 纹章图案可分为三种不同类型。类型 I 的特点是以两个天球仪环抱曼努埃尔一世国王的盾徽, 是最早且最富丽堂皇的类型。据该学者所述, 此种类型见于 1500 至 1518 年间制作的宪章。类型 II 是最简洁的类型, 其特点是在方形或矩形几何构图中有一个装饰性大写字母 "D", 内部嵌入曼努埃尔一世国王的盾徽。该学者认为, 类型 II 常见于 1510 至 1512 年间的宪章。类型 III 的特点是将曼努埃尔一世国王的盾徽置于一个四等分背景中的大写字母 "D" 内。

继 1500 年里斯本宪章改革之后, 埃武拉宪章是第二个进行改革的宪章 (1501 年 9 月 1 日)。该宪章采用类型 I, 以两个天球仪环抱

1. Introduction

During the sixteenth century, the Portuguese King D. Manuel I (1469-1521) undertook an important reform of the Charters of the Cities and Villages of the Kingdom. It is believed that circa 580-600 Manueline Charters were produced in the short period of the first two decades of the sixteenth century. Although the Charter's texts were competence and responsibility of the Kingdom authorities, the local townships financially supported the production of the Charters, namely its illuminations. In this sense, a comparative study of the materials and paintings techniques of these illuminated manuscripts strongly reflects the cultural, political and financial capabilities of each City and Village at the time of its production. According to Garcia, three different typologies of the heraldic representations of the Charters frontispiece can be found in the Manueline Charters. Characterized by the representation of King's D. Manuel I arms flanked by two armillary spheres, type I is the earliest and the richest typology which, according to the same author, can be found in Charters produced between 1500 and 1518. Type II is the simplest typology, characterized by an ornamented capital "D" inscribed in a square or rectangular geometry, in which the arms of King D. Manuel I are inserted. According to the same author, type II is commonly found in a quadripartite background. Despite starting to be used in 1512, it was after 1514

曼努埃尔一世国王的盾徽。本研究所涉及的其他三份宪章——阿尔科谢蒂、特雷纳和阿尔多阿尔宪章——均属于类型 III（因此，曼努埃尔一世国王的盾徽被置于四等分背景中的大写字母“D”内），并且几乎制作于同一时期：阿尔科谢蒂（1515 年 1 月 17 日）、阿尔多阿尔（1516 年 1 月 15 日）和特雷纳（1516 年 1 月 16 日），如图 1 所示。

文艺复兴时期的泥金彩绘颜料主要由着色剂（可以是颜料或色淀颜料）和结合剂（例如蛋白质类，或更常见的多糖类）组成。通常还会添加填料，以改善颜料的机械性能和不透明度，同时不显著改变其最终色调。

对泥金彩绘进行分析是一个具有挑战性的过程。多年来，对泥金彩绘的分析仅限于目视观察和原位分析。然而，关于有机与无机颜料混合物以及结合剂混合物的一些问题，由于这些非侵入性技术的特异性较低而受到限制。近年来，无损取样分析的进展使得更可靠的分析成为可能。另一方面，随着仅需纳克级样品量的分析技术的发展，获取知识所付出的样品损伤代价已显著降低。从这个意义上说，如果由高技术水平的专业人员精心规划和操作，微量取样可以成为解答泥金手抄本制作背后问题的重要工具。在过去十年中，已有多项关于葡萄牙曼努埃尔风格宪章制作材料的研究。然而，已发表的文献中，尚无研究基于对泥金装饰卷首插画的材料和颜料表征的系统分析方法，对多份宪章进行协同比较。

本研究对阿尔科谢蒂、特雷纳、阿尔多阿尔

that its use became predominant.

After the reform of the Charter of Lisbon in 1500, the Charter of Evora was the second Charter to be reformed (1 September 1501). With King's D. Manuel I arms flanked by two armillary spheres, it follows the type I typology (Fig. 1). The other three Charters included in this work—the Charters of Alcochete, Terena and Alandroal—belong to type III (hence King's D. Manuel I arms are inscribed in the capital “D” in a quadripartite background) and were almost contemporaneously produced: Alcochete (17 January 1515), Alandroal (15 January 1516) and Terena (16 January 1516), as shown in Fig. 1.

An illuminated Renaissance colour paint is mainly composed by a colourant (that could be either a pigment or a lake pigment) and a binder (such as a proteinaceous or, more frequently, a polysaccharide). Usually, an extender was added to improve the mechanical properties of the paint and its opacity, without significantly changing its final hue.

The characterization of illuminated paints is a really challenging process. For many years, the analysis of illuminated paints was restricted to visual observation and to in situ analysis. Nevertheless, some questions regarding the use of mixtures of organic and inorganic pigments, and mixtures of binders were restricted by the low specificity of these non-invasive techniques. Recent advances in non-sampling analysis have allowed to more consistent analysis. On the other hand, the development of analytical techniques requiring up to ng of samples significantly decreased the damage-to-knowledge ratio. In this sense, if well planned and performed by a highly skilled technician,



图 1: 规格归一化后的图像: a 阿尔科谢蒂宪章 (286 毫米 × 173 毫米), b 特雷纳宪章 (180 毫米 × 235 毫米), c 阿尔多阿尔宪章 (195 毫米 × 280 毫米), d 埃武拉宪章 (290 毫米 × 208 毫米)
Figure 1. Normalized size images of the Charters of a Alcochete (286 mm × 173 mm), b Terena (180 mm × 235 mm), c Alandroal (195 mm × 280 mm) and d Evora (290 mm × 208 mm).

尔和埃武拉四份宪章制作中所用的材料及颜料配方进行了系统比较。研究采用了光学显微镜和光谱学分析(显微拉曼光谱、显微傅里叶变换红外光谱和扫描电子显微镜-能谱仪),并结合化学计量学方法。这些分析为宪章制作提供了有价值的特征指纹,为重新审视葡萄牙曼努埃尔风格宪章在文艺复兴时期的制作视角做出了贡献。

2. 方法

本研究首先在体视显微镜下仔细观察泥金彩绘部分,目的是评估其保存状况、辨别所用材料在性质上的差异、判断颜料是否存在退化现象,并最终确定可以进行微区取样的区域。微区取样综合考虑了样本的代表性、最小干预原则以及每种分析技术所需的最小样本量。对微区样本进行了扫描电子显微镜-能谱仪(SEM-EDS)、显微拉曼光谱(μ -Raman)和显微红外光谱(μ -FTIR)分析。四份曼努埃尔风格宪章均遵循相同的分析流程,以确保数据的可比性。

2.1 光学显微镜与微区采样

微区采样在颜料的缺失区域进行,使用 Ted Pella 公司微工具中的微型凿子,在配备 LEICA DFC295 相机和光纤外部照明的 LEICA M205C 体视显微镜下操作(变倍范围为 7.89 倍至 1609 倍),获取的微区样本尺寸介于 20 至 50 微米之间。

2.2 扫描电子显微镜-能谱分析

能谱分析使用的是日立 3700N 型可变压力扫描电子显微镜,并搭配了布鲁克 Xflash 5010 SDD 型能谱仪。样本在 40 Pa 的气压下进行分析(样品无提前镀膜)。使用背散射电子模式进行扫描电镜成像。该能谱探测器在锰(Mn)的 $K\alpha$ 特征 X 射线处的能量分辨率为 123 eV。该系统能够进行可靠的点化学分析和元素面分布分析,检测范围从钠(Na)的 $K\alpha$ 线到最重元素的 L 线。为了采集铅(Pb)这类重元素的 X 射线信号,选择 20kV 的加速电压。能谱数据的采集和定量计算均由布鲁克公司自带的

micro-sampling might turn into an important tool to answer the questions behind the production of illuminated manuscripts. In the last decade, several studies on the materials used to produce Portuguese Manueline Charters were performed. Nevertheless, none of the published works concerned the concerted comparison of several Charters based on a systematic analytical approach of the materials and paint characterization of its illuminated frontispiece.

In this work, a systematic comparison between the materials and the paints formulations used to produce the Charters of Alcochete, Terena, Alandroal and Evora is presented. Optical microscopy and spectroscopic analysis (μ -Raman, μ -FTIR and SEM-EDS) following a chemometric approach were used. Interesting fingerprints for the Charters' production contributed to a new vision on the perspective of the production of the Portuguese Manueline Charters during the Renaissance period.

2. Methodology

The study started with a detailed observation of the illuminations under a stereomicroscope to assess its state of conservation, to identify differences in the nature of the materials used, the existence of degradations in paints and, finally, to establish the possible micro-sampling areas. Micro-sampling took into account the need for representativeness, the importance of minimum intervention and sample minimum amounts required for each analytical techniques used. SEM-EDS, μ -Raman and μ -FTIR analysis were performed in micro-samples. A similar analytical approach was followed for the four Manueline Charters to enable reliable data comparison.

2.1 Optical microscopy and micro-sampling

Micro-sampling was performed in lacunas with a micro-chisel from Ted Pella micro-tools (micro-samples ranging between 20 and 50 μ m) under a LEICA M205C stereomicroscope with a zoom range of 7.89 to 1609 equipped with a LEICA DFC295 camera and an external illumination by optical fibres.

2.2 SEM-EDS

SEM-EDS analyses were performed

Esprit 1.9 软件完成。

2.3 显微拉曼光谱分析

采用 HORIBA X Plora 型拉曼光谱仪进行微区样本分析, 该仪器配备 785 纳米波长的二极管激光器 (输出功率 28 毫瓦), 并与奥林巴斯显微镜搭配使用。光谱采集范围为 $100 - 2000\text{ cm}^{-1}$, 采用扩展模式。激光通过奥林巴斯 50 倍的物镜聚焦, 到达样品表面的激光功率为总功率的 1% - 10%, 每次曝光时间为 10 秒, 累计扫描 10 次以提高信噪比。

2.4 显微红外光谱分析

使用的是布鲁克 Hyperion 3000 型红外光谱仪, 该仪器配备液氮冷却的单点汞镉碲 (MCT) 检测器及 15 倍物镜。光谱在透射模式下进行测量, 分析区域为 50-100 微米, 采用日本 S.T. 公司的金刚石压池制样。红外光谱采集参数为: 分辨率 4 cm^{-1} , 扫描次数 32 次, 采集范围在 $4000-650\text{ cm}^{-1}$ 。

2.5 主成分分析

为消除基线漂移和无关的光散射效应, 首先使用 MATLAB[®] (7.11 版) 和 Eigenvector Research 公司的 PLS 工具箱 (5.5.1 版) 对光谱数据进行预处理。对采集到的 36 张历史样本红外光谱依次进行了基线斜率校正、标准正态变量变换 (SNV), 并通过减去各光谱的最小值进行正性校正。随后, 采用 Savitzky-Golay 滤波器对光谱进行平滑处理, 窗口大小为 15 个数据点, 采用二阶多项式拟合, 并计算一阶导数。主成分分析 (PCA) 聚焦于红外光谱的 C-H 吸收区域 ($3000 - 2840\text{ cm}^{-1}$), 该区域的选择基于前期已发表的研究成果。为识别样本中结合剂的类型, 将历史样品的红外光谱投影至一个预先建立好的 PCA 模型上。该模型是通过分析 58 种纯结合剂 (包括羊皮纸胶、蛋清、蛋黄、酪蛋白胶, 以及阿拉伯树胶、黄蓍胶和杏仁胶, 均按历史配方重现制备) 的红外光谱所构建的。

3. 实验结果

3.1 着色剂与填料

with a variable pressure scanning electron microscope HITACHI 3700 N coupled to an energy-dispersive X-ray spectrometer Bruker Xflash 5010 SDD EDS. Samples were analysed under an air pressure of 40 Pa (with uncoated samples). The backscattering mode was used for SEM imaging. The resolution of the EDS detector is 123 eV at the Mn Ka line energy. The system allows reliable chemical point analysis and mapping from Na Ka X-ray emission energy up to the L emissions of the heaviest elements. In order to collect X-ray emissions from heavier elements like Pb, an acceleration voltage of 20 kV was chosen. The EDS tasks and the quantification were achieved through the Esprit 1.9 software from Bruker Corporation.

2.3 μ -Raman

A Raman spectrometer HORIBA XPlora equipped with a diode laser of 28 mW operating at 785 nm, coupled to an Olympus microscope, was used for the analysis of the micro-samples. Raman spectra were acquired in extended mode in the $100-2000\text{ cm}^{-1}$ region. The laser was focused with an Olympus 50x lens, 1-10% of the laser power on the sample surface (10s of exposure, 10 cycles of accumulation).

2.4 μ -FTIR

An infrared spectrometer Bruker Hyperion 3000 equipped with a single point MCT detector cooled with liquid nitrogen and a 15x objective lens was used. The spectra were collected in transmission mode, in $50-100\text{ }\mu\text{m}$ areas, using a S.T. Japan diamond anvil compression cell. The infrared spectra were acquired with a spectral resolution of 4 cm^{-1} , 32 scans, in the $4000-650\text{ cm}^{-1}$ of the infrared region.

2.5 PCA analysis

Spectral pre-processing was used to remove baseline drifts and unwanted light-scattering effects using MATLAB[®] (version 7.11) and PLS toolbox (version 5.5.1) from Eigenvector Research Inc. The 36 infrared spectra of historical samples were pre-processed for a baseline slope correction, followed by standard normal variate (SNV) and positivity correction by subtracting each spectrum from its minimum value. Spectra were further processed with a Savitzky-Golay filter with 15-point window size, second order

采用扫描电子显微镜-能谱 (SEM-EDS)、显微拉曼光谱 (μ -Raman) 和显微红外光谱 (μ -FTIR) 对四份曼努埃尔宪章中的彩绘颜料进行了材质鉴定, 识别出了文艺复兴时期用于泥金彩绘的最具代表性的材料。对金色颜料的能谱分析表明, 其采用高纯度金铜合金制作 (金含量约 99%); 银色颜料则采用高纯度银铜合金 (银含量约 99%)。显微拉曼光谱分析确认, 红色颜料使用了朱砂 (α -HgS), 橙色颜料则使用了铅丹 (Pb_3O_4)。朱砂通过其特征拉曼谱峰得以识别: 252cm^{-1} 和 286cm^{-1} 处的谱峰归属于 S-Hg-S 键角弯曲振动, 343cm^{-1} 处的谱峰归属于 Hg-S 键伸缩振动, 如图 2a 所示。除了这些亮红色的朱砂颜料外, 还普遍使用了一种深红色颜料。尽管其发色团尚未明确表征, 但对这些深红色区域的能谱分析发现了铝、硫和钾元素, 这是明矾 [$\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$] 的特征成分。这一发现支持了使用红色色淀颜料 (如茜草色淀或胭脂虫色淀) 的推测。不过, 要确

polynomial and first derivative. Principal component analysis (PCA) was applied to the C-H absorption region ($3000\text{--}2840\text{ cm}^{-1}$) of the infrared spectra. This absorption region was selected based on previous studies already published. Infrared spectra of historical samples were projected on a PCA model calibrated with 58 infrared spectra of pure binders (parchment glue, egg white, egg yolk, casein glue, Arabic, Tragacanth and almond gums reproduced following historical recipes)

3. Results

3.1 Colourants and extenders

SEM-EDS, μ -Raman and μ -FTIR were used for the material characterization of the illuminations found in the four Manueline Charters. The most characteristic materials for producing illuminations during the Renaissance period were identified. SEM-EDS analysis of gold paints highlighted its production with high pure gold-copper alloys (circa 99%), silver with high silver-copper alloys (circa 99%). Raman microscopy identified the use of vermilion (α -HgS) for producing reds and of red lead (Pb_3O_4) for the oranges. Vermilion was identified through its characteristic Raman bands at 252 and 286 cm^{-1} ascribed to the d(S-Hg-S) angle bending, and the band at 343 cm^{-1} attributed to the m(Hg-S) stretching, as shown in Fig. 2a. Besides these bright-red vermilion paints, a dark red was consistently used. Although its chromophore was not yet characterized, SEM-EDS analysis of these dark reds identified the presence of aluminium, sulphur and potassium, characteristic of alum ($\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$). This fact supports the idea of the use of a red lake pigment, such as madder or cochineal lake. Nevertheless, LC-DAD/MS would be fundamental to identify the kind of red dye used to produce these red lakes. Red lead was identified by its two intense bands at 123 and 553 cm^{-1} ascribed to the m(Pb-O) stretching vibrations, two low-intense bands at 153 and 395 cm^{-1} ascribed to the (O-Pb-O) vibrational modes and a low-intense band at 228 cm^{-1} due to d(O-Pb-O) bending angle, as shown in Fig. 2b.

Blue paints were produced with azurite [$\text{Cu}_3(\text{CO}_3)_2(\text{-OH})_2$], which was identified through its characteristic Raman

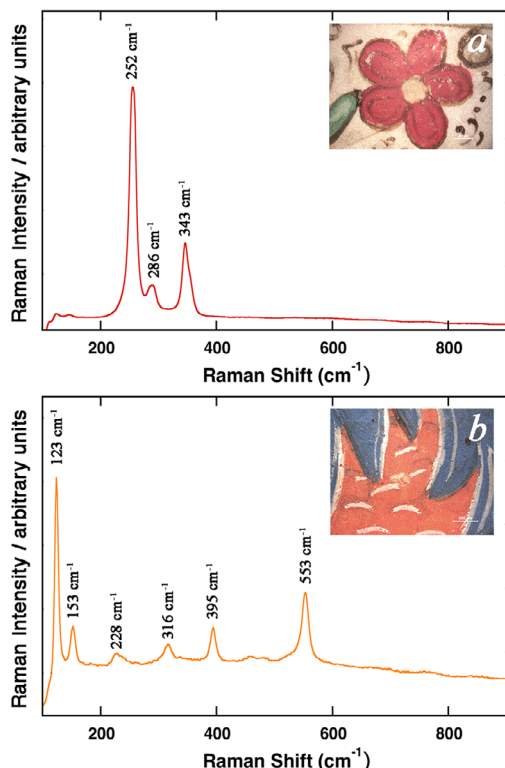


图 2: 特雷纳宪章中红色和橙色泥金彩绘颜料的拉曼光谱: a 朱砂的特征拉曼光谱; b 铅丹的特征拉曼光谱。
Figure 2. Raman spectra of red and orange paints illuminations in the Charter of Terena: a characteristic Raman spectra of vermilion; b characteristic Raman spectra of red lead.

定制备这些红色色淀所用的具体染料种类, 还需要进行液相色谱——二极管阵列检测器/质谱(LC-DAD/MS)分析。铅丹通过其特征拉曼谱峰得以识别: 123cm^{-1} 和 553cm^{-1} 处的两个强峰归属于 Pb-O 键伸缩振动, 153cm^{-1} 和 395cm^{-1} 处的两个弱峰归属于 O-Pb-O 振动模式, 228cm^{-1} 处的弱峰归属于 O-Pb-O 键角弯曲振动, 如图 2b 所示。

蓝色颜料使用的是蓝铜矿 [$\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$], 其通过 175 、 249 、 403 、 760 、 937 和 1098cm^{-1} 处的特征拉曼谱峰得以确认, 如图 3 所示。其中, 249cm^{-1} 和 403cm^{-1} 处的谱峰归属于 Cu-O 基团的振动, 具体而言, 249cm^{-1} 对应 O-Cu-OH 弯曲振动, 403cm^{-1} 对应 Cu-O 键伸缩振动。

在特雷纳宪章中, 装饰边框的绿色区域检测到了孔雀石 [$\text{Cu}_2(\text{CO}_3)(\text{OH})_2$]; 而在大写首字母的绿色区域中, 孔雀石则与水胆矾 [$\text{Cu}_4\text{SO}_4(\text{OH})_6$] 共存。这两种化合物均通过其特征红外吸收谱带得以识别: 孔雀石的特征吸收包括 3402 和 3322cm^{-1} (O-H 伸缩振动)、 1511 和 1400cm^{-1} (CO_3^{2-} 伸缩振动)、 1096 和 1050cm^{-1} (O-H 弯曲振动), 以及 876 、 821 和 750cm^{-1} (O-C-O 弯曲振动); 水胆矾的特征吸收则包括 3588 、 3568 和 3384cm^{-1} (O-H 伸缩振动), 以及 1119 和 1087cm^{-1} (SO_4^{2-} 伸缩振动), 如图 4 所示。此外, 对特雷纳宪

bands at 175 , 249 , 403 , 760 , 937 and 1098cm^{-1} , as shown in Fig. 3. The bands observed at 249 and 403cm^{-1} are assigned to the vibrations of the Cu-O group, namely to the O-Cu-OH bending vibration (249cm^{-1}) and to the Cu-O bond stretching (403cm^{-1}).

For the Charter of Terena, malachite [$\text{Cu}_2(\text{CO}_3)(\text{OH})_2$] was found in the greens present in the illuminated frame, whereas in the capital letter, malachite was found together with brochantite [$\text{Cu}_4\text{SO}_4(\text{OH})_6$]. Both compounds were identified by their characteristic IR absorption bands as shown in Fig. 4. μ -Raman analysis of another green paint micro-sample from a different green area of the Charter of Terena's capital letter allowed to identify the presence of the characteristic Raman bands of two different copper sulphates: brochantite [$\text{Cu}_4\text{SO}_4(\text{OH})_6$] and posnjakite [$\text{Cu}_4\text{SO}_4(\text{OH})_6 \cdot \text{H}_2\text{O}$], as shown in Fig. 5.

Although in the last years copper sulphates were identified as a pigment in illuminated manuscripts by several authors, SEM-EDS analysis of green paints from the Charter of Terena found copper pervasively present in combination with sulphur only in localized regions. This fact suggests that brochantite and posnjakite might result from the alteration of malachite, originally used in the production of these green paints, and not from its use as a pigment.

Finally, chalk (CaCO_3) was extensively used as extender. For the lightening and for the whites, lead white [$2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$] was the white pigment used by the illuminators.

From the four Charters considered in this work, only the Charter of Evora present decorative motifs painted in yellow. μ -Raman analysis identified the characteristic Raman bands ascribed to the presence of lead tin yellow (type I) at 130 , 197 , 275 , 290 , 455 and 524cm^{-1} , as shown in Fig. 6.

Lead tin yellow (type I) was also identified in the Charter of Alcochete, but in some goldish details, not in the yellow paints (as this colour is absent in the palette of this Charter). Regarding green paints, a different copper-based pigment not yet fully characterized was found in the Charter of Evora. Under magnified observation, it presents a deeper hue. SEM-EDS analysis did not find copper related

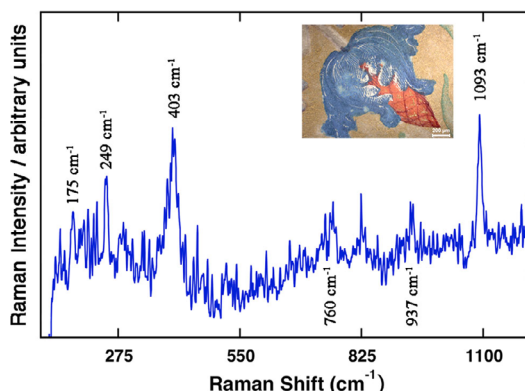


图 3: 埃武拉宪章中蓝色泥金彩绘颜料的拉曼光谱, 图中标注了蓝铜矿的特征拉曼谱峰。

Figure 3. Raman spectrum of a blue paint illumination in the Charter of Evora, where azurite was identified through its characteristic Raman bands signed in the spectrum.

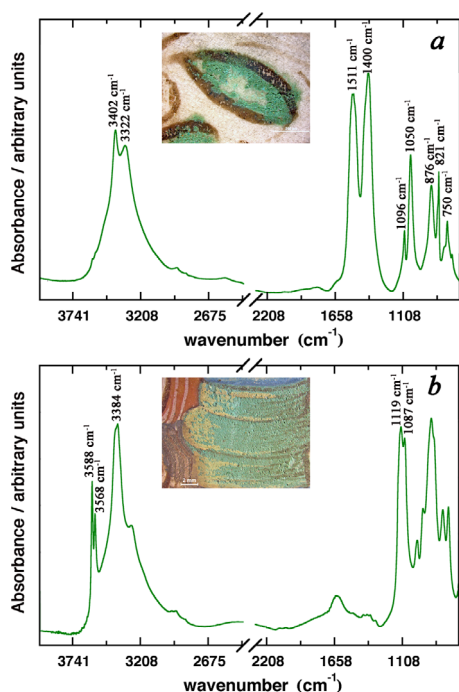


图4: 特雷纳宪章中绿色泥金彩绘颜料的红外光谱: a 孔雀石的特征红外光谱; b 水胆矾的特征红外光谱。

Figure 4. Infrared spectra of green paints illuminations in the Charter of Terena: a characteristic infrared spectra of malachite; b characteristic infrared spectra of brochantite.

章大写首字母中另一处不同绿色区域的微区样品进行显微拉曼光谱分析, 结果显示两种不同硫酸铜的特征拉曼谱峰, 分别为水胆矾 $[\text{Cu}_4\text{SO}_4(\text{OH})_6]$ 和波姆矿 $[\text{Cu}_4\text{SO}_4(\text{OH})_6 \cdot \text{H}_2\text{O}]$, 如图5所示。

对特雷纳宪章绿色颜料的能谱分析发现, 铜元素虽然普遍存在, 但与硫元素结合的情况仅出现在局部区域。这一结果表明, 水胆矾和波姆矿很可能是孔雀石(最初用于制作这些绿色颜料的原料)的变质产物, 而非作为颜料直接添加的。

最后, 彩绘师们普遍使用白垩(CaCO_3)作为填料。而在需要提亮颜色或表现白色区域时, 则采用的是铅白 $[2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2]$ 作为白色颜料。在本研究的四份宪章中, 仅有埃武拉宪章的装饰图案使用了黄色。显微拉曼光谱分析在130、197、275、290、455和524 cm^{-1} 处识别出铅锡黄(类型I)的特征拉曼谱带, 如图6所示。

铅锡黄(类型I)同样在阿尔科谢蒂宪章

to sulphur nor to chlorine. FTIR analysis suggests the presence of a copper-based acetate, but the results are not clear. μ -FTIR and SEM-EDS analysis of the blue sky paints of the Charter of Alcochete identified the presence of two light blue formulations: a deeper layer produced with azurite and lead white (that might correspond to the original paint); and a superficial light blue layer produced with azurite and titanium dioxide. Considering that titanium dioxide began to be used as a white pigment for painting in 1920-1930s as lead white substitute, its generalized presence in the blue sky paints formulation evidence its application in the twentieth century as a way to bridge possible existing heterogeneities in these illuminations. It is thus justified the unusual bright colours found in the Charter of Alcochete. Important to stress is the fact that this intervention was unknown by the owner of the Charter of Alcochete. In this sense, its materials characterization allowed to infer more on the knowledge of its history.

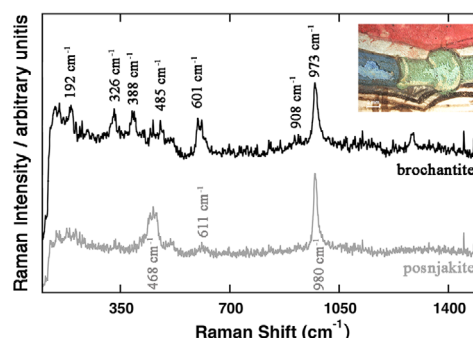


图5: 特雷纳宪章大写首字母中绿色泥金彩绘颜料的拉曼光谱, 图中标注了水胆矾和波姆矿的特征拉曼谱峰。

Figure 5. Raman spectrum of the green paint illuminations in the capital letter of the Charter of Terena, where brochantite and posnjakite were identified through its characteristic Raman bands signed in the spectra.

3.2 Colourants and extenders

PCA analysis of 36 infrared spectra of blue historical samples from the Charters of Alcochete, Terena, Alandroal and Evora followed a calibrated model with infrared spectra of pure proteinaceous and polysaccharide binders (parchment glue, egg white, egg yolk, casein glue and Arabic, Tragacanth, Almond gums, respectively). Representative infrared spectra of these binders are presented as Supplementary Material. As it was aimed to proceed with a comparative analysis of the binders used on

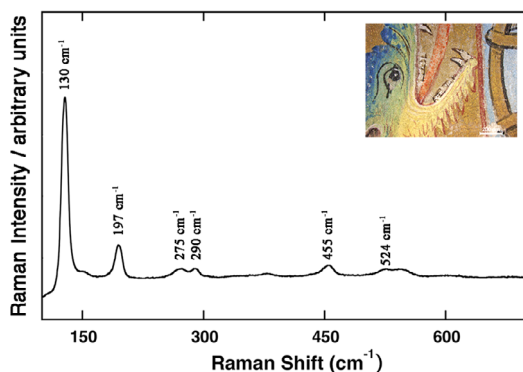


图6: 埃武拉克章中黄色颜料的拉曼光谱, 图中标注了铅锡黄(类型I)的特征拉曼谱峰。

Figure 6. Raman spectrum of a yellow paint from the Charter of Evora, where lead tin yellow (type I) was identified through its characteristic Raman bands signed in the spectra. infrared spectra of brochantite.

中被检测到, 但出现在某些具有金色质感的细节中, 而非黄色颜料区域。至于绿色颜料, 在埃武拉克章中发现了一种不同的铜基颜料, 其具体成分尚未完全确定。在放大观察下, 这种绿色呈现出更深的色调。能谱分析未发现铜与硫或氯相关, 而红外光谱分析则暗示可能存在一种铜基醋酸盐, 但结果尚不明确。对阿尔科谢蒂宪章中蓝色天空颜料的显微红外和能谱分析显示, 该区域存在两种浅蓝色配方: 较深的底层由蓝铜矿和铅白组成, 可能为原始颜料层; 而表层的浅蓝色层则由蓝铜矿和二氧化钛组成。考虑到二氧化钛在20世纪20至30年代才开始作为铅白的替代品用于绘画, 其在蓝色天空颜料配方中的广泛存在, 表明该宪章在20世纪曾经历过修复, 以弥补彩绘中可能存在的不均匀。这也解释了阿尔科谢蒂宪章中异常鲜艳色彩的成因。需要强调的是, 宪章所有者此前对此修复干预并不知情。因此, 这将有助于我们更深入地了解其历史。

3.2 结合剂配方

由于本研究旨在对四份曼努埃尔宪章制作中所用的结合剂进行比较分析, 因此选择一种在四份宪章中均有出现、位于相似装饰主题中、且在红外区域具有良好吸收的颜色至关重要。基于此考虑, 蓝色颜料被选中, 不仅因为它普遍存在于四份曼努埃尔宪章中, 还因为蓝色颜料主要由蓝铜矿和结合剂组成, 其光谱在C-H

Charters, it was important to choose a colour represented among the four Charters, in similar decorative motifs, and with a good absorption in the infrared region. In this sense, blue paints were chosen not only because are ubiquitously present in the four Manueline Charters, but also because blue paints are mainly composed of azurite and the binder, displaying a clear spectral window for the C-H absorptions ($3000\text{--}2840\text{ cm}^{-1}$) that will be mainly the response of the binders present in the paints composition. A representative infrared spectrum of azurite is presented as Supplementary Material. The score analysis was based on the analysis of the loadings for PC1 and PC2 of each infrared spectrum. The first principal component (PC1) includes circa 80% of the variability of the infrared spectra restricted to the C-H absorption region and concerns the variability on the infrared spectra related to the absorption bands at 2923 and 2850 cm^{-1} . The second principal component (PC2) includes circa 17% of the variability in the infrared spectra restricted to the same region. PC2 concerns the variability on the absorption bands at 2965 cm^{-1} and 2936 cm^{-1} .

PCA scores projection evidences a trend on the dispersion of the scores of the infrared spectra between the triglyceride-based binders (casein and egg yolk) and the polysaccharide binders (tragacanth, almond and arabic gums). The higher dispersion found for Alcochete scores highlights the use of a different binding media composition for the restoration process, when compared with the one used for the production of the illuminations (extemporaneous paints reflected an higher amount of triglyceride-based content, when compared to the inner layers—that might correspond to the original formulations—that present a higher content on polysaccharides). The references for the mixture of a polysaccharide and glair are widely present in the Renaissance treatises. Nevertheless, the references for the mixture of a polysaccharide with triglyceride-based binders are absent. Preliminary Py-GC/MS results of three blue paint micro-samples from the Charters of Terena, Alandroal and Evora corroborated the presence of fatty acids in these paint formulations. However, it was not detected the presence

吸收区域 ($3000-2840\text{cm}^{-1}$) 具有清晰的窗口, 该区域的吸收主要反映颜料组成中结合剂的信息。PCA 得分散点图显示, 基于甘油三酯的结合剂与多糖类结合剂在得分分布上呈现出明显的区分趋势。阿尔科谢蒂宪章的得分较为分散, 这凸显了其修复过程中使用了与原始彩绘制作不同的结合介质配方: 与内层相比, 表层临时调配的颜料中甘油三酯含量更高。

关于多糖与蛋白胶混合使用的记载, 在文艺复兴时期的论著中广泛存在。然而, 关于多糖与甘油三酯类结合剂混合的记载则未见提及。对特雷纳、阿兰多阿尔和埃武拉宪章中三个蓝色颜料微区样品的初步分析结果证实了这些颜料配方中存在脂肪酸。但未检测到蛋白胶或胶原蛋白的标志物。这些新颖且有意义的结果目前正在进一步研究中, 以期更深入地理解这些葡萄牙曼努埃尔宪章制作中结合剂配方的独特性。

4. 结论

通过对四份曼努埃尔风格宪章所用材料的比较, 凸显了它们之间有趣的差异, 即不同颜料的使用 (例如阿尔科谢蒂和埃武拉宪章中使用的铅锡黄) 以及不同颜料配方的使用 (例如甘油三酯与多糖的混合物)。借助这些新颖且具有揭示性的发现, 我们对艺术史学家关于文艺复兴时期葡萄牙曼努埃尔风格宪章制作的观点有了新的认识——艺术史学者通常认为其泥金彩绘制作使用了蛋白质类和 / 或多糖类结合剂。为此, 本研究采用的红外光谱与化学计量学相结合的方法至关重要, 因为这种方法能够更深入地推断这些泥金彩绘制作的特殊性, 而仅通过直接的光谱分析是很难做到这一点的。

pyrrole for collagen). These new and interesting results are now being investigated, in order to better understand the specificities behind the binding media formulations used in the production of these Portuguese Manueline Charters.

4. Conclusion

The comparison of the materials used to produce the Manueline Charters of Alcochete, Terena, Alandroal and Evora highlighted interesting differences between them, namely the use of different pigments (such as lead tin yellow in the Charters of Alcochete and Evora) and of different paints formulations (such as mixtures of triglycerides and polysaccharides). With these new and revealing findings, a new insight into the Art Historian perspective for the production of the Portuguese Manueline Charters during the Renaissance period that frequently refers the use of proteinaceous and/or polysaccharides binders for the production of its illuminations was achieved. For this, the approach followed in this work based on combining infrared spectroscopy and chemometrics was fundamental, as it allowed infer more on the specificities of the production of these illuminations that with a direct spectral analysis would have been very difficult to achieved.

活动报道 Latest Events

第五届联合国教科文组织名录遗产与可持续发展黄山对话会 The Fifth Huangshan Dialogue on UNESCO-designated Sites and Sustainable Development

资料来源 Source:

<https://cnews.chinadaily.com.cn/a/202606/01/WS6a1d517ba310942cc49af6fb.html>



图1：大会现场
Figure 1. The scene of the conference

2026年5月31日至6月1日，第五届联合国教科文组织（UNESCO）名录遗产与可持续发展黄山对话会（简称“UNESCO 黄山对话会”）在安徽省黄山市举办。

为期两天的会期中，各国文化部长们与文化专家围绕《2022 宣言》六大优先领域展开深入探讨——从遗产保护到文化创意产业推进，议题广泛而紧迫。会议另设两项专题焦点：确保文化政策的包容性，以及谋划文化融入“后2030”全球发展框架的路径。中国科学院院士、联合国教科文组织国际自然与文化遗产空间技术中心（HIST）主任郭华东在开幕式致辞中表示，HIST作为UNESCO在全球设立的唯一一个基于空间技术的世界遗产研究中心，已初步建成全链条名录遗产治理体系。他呼吁，加大数智技术的应用，促进跨学科国际科研合作，加强发展中国家的能力建设，推动基于数智技术的遗产保护理论体系、学科体系和人才体系的构建，更好地应对民族遗产面临来自自然环境变化和人类不当行为的挑战。他欢迎全球相关机构加入数字可持续发展国际大科学计划，

From May 31 to June 1, 2026, the Fifth Huangshan Dialogue on UNESCO-designated Sites and Sustainable Development (hereinafter referred to as the “UNESCO Huangshan Dialogue”) was successfully held in Huangshan, Anhui Province.

Guo Huadong, Academician of the Chinese Academy of Sciences and Director of HIST, stated that HIST, as the only UNESCO centre worldwide focusing on space technology-based world heritage research, has initially established a full-chain governance system for designated heritage. He called for greater application of digital and intelligent technologies, interdisciplinary international collaboration, capacity-building in developing countries, and the development of theoretical, disciplinary, and talent training systems for heritage protection. These efforts, he noted, are essential to better address challenges facing heritage sites from environmental changes and inappropriate human activities. He welcomed global institutions to join the International Science Program on Digital Sustainable Development, working together to accelerate the implementation of the UN 2030 Agenda through digital and intelligent technologies.

Lazare Eloundou Assomo, Acting Assistant Director-General for Culture at UNESCO and Director of the World Heritage Centre, noted that “UNESCO designated heritage sites represent the world’s most unique cultural and natural treasures. They not only protect precious biodiversity and safeguard humanity’s cultural heritage, but also support the development of local communities, vividly demonstrating the inseparable relationship between people and nature.”

学界普遍认为，此次会议共同利用数智技术加快联合国 2030 年可持续发展议程的落实。

UNESCO 文化部门代理助理总干事、世界遗产中心主任拉扎尔·埃隆杜·阿索莫在视频致辞中指出，“UNESCO 名录遗产是世界上最具独特价值的文化和自然瑰宝。它们不仅保护着珍贵的生物多样性，守护着人类文化遗产，也支持着当地社区发展，生动地展现了人与自然之间密不可分的关系。”

本届会议主题为“数智技术驱动名录遗产可持续发展”。会议围绕人工智能与数字考古、气候变化、生物多样性保护、名录遗产风险监测评估、可持续旅游与社区发展等议题组织多场分会，并特别设置 UNESCO 名录遗产申报和推介专场，由 UNESCO 世界遗产中心、UNESCO 生态与地学司等机构权威专家解读世界遗产、生物圈保护区、地质公园最新申报政策，为国内名录遗产申报工作提供专业支撑。

站在新的起点上，UNESCO 黄山对话会将持续发挥国际平台作用，深化与 UNESCO 及全球各成员国合作，推动数智技术与遗产保护深度融合，为全球名录遗产保护与发展提供创新解决方案。

The theme of this year's Dialogue was "Digital and Intelligent Technologies Driving the Sustainable Development of Designated Heritage." In line with this theme, multiple sessions were organized covering topics such as artificial intelligence and digital archaeology, climate change, biodiversity conservation, risk monitoring and assessment of designated heritage sites, and sustainable tourism and community development. A special session was also held on the nomination and promotion of UNESCO designated heritage sites, during which leading experts from UNESCO's World Heritage Centre and the Division of Ecological and Earth Sciences provided in-depth interpretations of the latest nomination policies for World Heritage sites, Biosphere Reserves, and Global Geoparks, offering professional support for the nomination efforts of domestic heritage sites.

Building on a new starting point, the UNESCO Huangshan Dialogue will continue to play its role as an international platform, deepen cooperation with UNESCO and its member states worldwide, promote the deep integration of digital and intelligent technologies with heritage conservation, and provide innovative solutions for the protection and development of global designated heritage.

陕西中法文化遗产保护合作座谈与学术研讨会在法国巴黎举行

The Shaanxi-France Cultural Heritage Conservation Cooperation Symposium and Academic Seminar Held in Paris, France

资料来源 Source:

<https://cn.chinadaily.com.cn/a/202605/28/WS6a18337ea310942cc49aede6.html>

当地时间 5 月 28 日上午，陕西中法文化遗产保护合作座谈暨学术研讨会在法国巴黎成功举办。活动由秦始皇帝陵博物院与法国遗产科学基金会联合主办。

陕西省委常委、宣传部部长孙大光，陕西省文物局局长贾强以及陕西省委宣传部、陕西省文化和旅游厅代表出席活动。法国遗产科学基金会总干事埃马纽埃尔·巴洛、法国历史建筑研究室主任科琳娜·贝利耶，法国国家遗产学院国际关系专员路易莎·德罗纳参加活动。来自西北工业大学、陕西科技大学、法国蔚蓝海岸大学、法国博物馆研究与修复中心等中法

On the morning of May 28 local time, the Shaanxi-France Cultural Heritage Conservation Cooperation Symposium and Academic Seminar was successfully held in Paris, France.

Sun Daguang, Member of the Standing Committee and Director of the Publicity Department of the CPC Shaanxi Provincial Committee, and Jia Qiang, Director of the Shaanxi Provincial Cultural Heritage Administration attended the event. French participants included Emmanuel Barlaud, Executive Director of the Fondation des Sciences du Patrimoine; Corinne Belier, Director of the French Historical Monuments Research Laboratory; and



图 2: 会议现场
Figure 2. The scene of the event

高校与科研机构的专家学者共同参会。

座谈会上, 孙大光会见埃马纽埃尔·巴洛, 双方充分肯定中法在文化遗产保护领域十余年合作成果, 一致同意持续深化合作, 推动项目落地见效, 共同打造中法文明对话标志性品牌。埃马纽埃尔·巴洛介绍法方遗产保护科研体系与国际合作情况, 高度赞赏陕西在文物保护、国际协同创新方面的突出成效, 期待进一步拓展合作领域、提升合作层次。

贾强系统回顾陕西与法国在文化遗产保护领域的合作历程。他表示, 自 2014 年以来, 双方秉持平等互惠、优势互补、合作共赢原则, 扎实推进公输堂彩绘木作保护、茂陵石刻保护、秦始皇帝陵木质遗存与土遗址保护三大重点项目, 多项成果先后纳入中法高级别人文交流机制及两国元首外交成果清单, 成为国际文化遗产合作的典范。

学术研讨环节, 秦始皇帝陵博物院副院长周萍就中法合作秦兵马俑保护研究项目作专题进展汇报。中法专家学者围绕秦陵木质遗存保护、土遗址防风化与保水材料应用、多尺度结构表征、陶器科技考古与修复等前沿课题开展深入交流, 形成一系列学术共识, 为后续联合科研、技术攻关奠定坚实基础。

此次活动是落实中法两国元首外交共识、深化中法人文交流的具体行动, 也是陕西服务国家总体外交、推动国际文化遗产合作的重要实践。下一步, 陕法双方将以此次座谈为新起点, 持续推进文化遗产保护、科研平台共建、学术交流、人才培养等全方位合作, 携手守护人类文明瑰宝, 为中法全面战略伙伴关系持续健康发展贡献力量。

Louisa Deroualle, International Relations Officer of the National Institute of Cultural Heritage of France. The symposium also brought together experts and scholars from Chinese and French institutions.

During the symposium, the two sides affirmed over a decade of fruitful China-France cooperation in cultural heritage conservation and agreed to deepen collaboration, ensure project implementation, and jointly build a flagship brand for China-France dialogue among civilizations. Emmanuel Barlaud introduced France's research system and international cooperation in heritage conservation. He highly commended Shaanxi's achievements in cultural relic preservation and international collaborative innovation, and expressed anticipation for broader and higher-level cooperation.

Jia Qiang systematically reviewed the cooperation between Shaanxi and France in cultural heritage conservation. He noted that since 2014, both sides have steadily advanced three major projects: the conservation of the painted wooden structures at Gongshu Hall, the protection of stone carvings at Maoling Mausoleum, and the preservation of wooden remains and earthen sites at the Emperor Qinshihuang's Mausoleum.

During the academic seminar, Chinese and French experts held in-depth discussions on key topics, including the preservation of wooden remains from the Qin mausoleum, anti-weathering and water-retention materials for earthen sites, multi-scale structural characterization, and technological study and restoration of pottery.

This event implements the consensus of the Chinese and French heads of state and deepens bilateral people-to-people exchanges. Going forward, Shaanxi and France will use this symposium as a new starting point to enhance cooperation in heritage conservation, research platforms, academic exchanges, and talent cultivation. Together, they will safeguard human civilization and contribute to a healthy China-France comprehensive strategic partnership.

国际古迹遗址理事会非洲气候韧性土质建筑能力建设培训 ICOMOS Capacity-Building Training on Climate-Resilient Earthen Architecture in Africa

资料来源 Source:

<https://www.icomos.org/news/conclusion-training-climate-resilient-earthen-architecture-africa/>



图 3：国际古迹遗址理事会非洲气候韧性土质建筑能力建设培训集体照

Figure 3. Group photo of the ICOMOS Capacity-Building Training on Climate-Resilient Earthen Architecture in Africa

2026 年 5 月 4 日至 11 日，ICOMOS 与 ICOMOS 布基纳法索合作，并得到阿里夫支持，成功举办了在布基纳法索蒂贝莱皇家法院举办的“非洲气候韧性土制建筑能力建设项目”。该区域培训项目汇聚了来自 16 个非洲国家的 25 名早期和中期职业遗产专业人士，针对当今文化遗产面临的最紧迫挑战之一：气候变化对非洲土制建筑遗产的影响。

在整个非洲大陆，土制建筑遗产正日益受到洪水、干旱、风暴、侵蚀和长期环境恶化的威胁。这些与气候相关的压力加速了历史建筑的恶化，并直接影响维护和居住这些建筑的社区。

该培训在被列入世界遗产名录的蒂贝莱王室宫廷举办，为参与者提供了理论和实践工具，以便更好地评估、预防和应对影响土质遗产地的气候风险。蒂贝莱皇家宫廷作为一个独特的学习环境，参与者可以直接参与在气候压力下保护土制建筑。该遗址以其卡塞纳壁画传统和独特的土制建筑群闻名，提供了与当地社区和活遗产实践紧密相关的实际案例研究。

在为期八天的项目中，参与者参与了英法双语课程，结合了遗产保护方法论，气候风险评估，应急准备与灾害响应，实地演习，现场观察与记录，以及关于本地知识体系和传统土

From 4 to 11 May 2026, ICOMOS, in collaboration with ICOMOS Burkina Faso and with the support of ALIPH, successfully held the “Capacity-Building Programme for Climate-Resilient Earthen Architecture in Africa” at the Royal Court of Tiébélé in Burkina Faso. Bringing together 25 early and mid-career heritage professionals from 16 African countries, the regional training programme addressed one of the most pressing challenges facing cultural heritage today: the impact of climate change on earthen architectural heritage across Africa.

Across the African continent, earthen architectural heritage is increasingly threatened by floods, droughts, storms, erosion, and long-term environmental degradation. These climate-related pressures accelerate the deterioration of historic structures and directly affect the communities that maintain and inhabit them.

Hosted at the Royal Court of Tiébélé, inscribed on the UNESCO World Heritage List, the training programme provided participants with both theoretical and practical tools to better assess, prevent, and respond to climate risks affecting earthen heritage sites. The Royal Court of Tiébélé served as a unique learning environment where participants could directly engage with the realities of conserving earthen architecture under climate pressure. Known for its Kassena mural painting traditions and distinctive earthen compounds, the site offered practical case studies closely connected to local communities and living heritage practices.

Throughout the eight-day programme, participants engaged in bilingual English-French sessions combining: heritage conservation methodologies, climate risk assessment, emergency preparedness and disaster response, field-based exercises, site observation and documentation, and exchanges on local knowledge systems and traditional earthen construction techniques. The programme placed particular emphasis on integrating traditional knowledge into climate adaptation strategies. Participants

筑技术的交流。该项目特别强调将传统知识融入气候适应策略。参与者与当地利益相关者、工匠和社区代表交流，以更好地理解蒂贝莱保护工作的社会、文化和环境层面。实地活动和动手操作使参与者能够直接在现场应用保护原则，强化了本地根植且可持续的遗产保护方法的重要性。

该培训的圆满完成标志着在加强非洲应对气候变化的遗产保护能力方面迈出了重要一步。参与者有望将培训期间所学的方法、工具和经验运用到各自所在机构和专业网络中，为非洲范围内更广泛的土质遗产保护作出贡献。该倡议也反映了国际古迹遗址理事会（ICOMOS）及其合作伙伴的持续承诺，即在遗产领域支持立足本地、听取社区意见且可持续的气候行动方法。

exchanged with local stakeholders, craftspeople, and community representatives to better understand the social, cultural, and environmental dimensions of conservation work in Tiébélé. Field activities and hands-on exercises enabled participants to apply conservation principles directly on site, reinforcing the importance of locally grounded and sustainable approaches to heritage protection.

The completion of the training marks an important step in strengthening African capacities for climate-resilient heritage conservation. Participants are expected to reinvest the methodologies, tools, and experiences acquired during the programme within their institutions and professional networks, contributing to the broader protection of earthen heritage across Africa. The initiative also reflects the continued commitment of ICOMOS and its partners to supporting locally rooted, community-informed, and sustainable approaches to climate action in the heritage sector.



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